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# THE Festivus

Vol. 53(4)

November 2021



Fossil volutes  
from Australia

New *Angaria* species

Tree snail predation on frogs

*Canarium*, *Amphidromus* and more

Quarterly Publication of the San Diego Shell Club





# THE FESTIVUS

A publication of the San Diego Shell Club

Volume: 53

November 2021

ISSUE 4

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Photograph of *Siminia* sp. 50 feet in the inner harbor at Ambon Bay, Maluku Islands, Indonesia. Photo courtesy of Charles E. Rawlings. (Cover artistic credit: Rex Stilwill).

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The San Diego Shell Club was founded in 1961 as a non-profit organization for educational and scientific purposes. More particularly to enjoy, study and promote the conservation of Mollusca and associated marine life through lectures, club meetings and field trips. Our membership is diverse and includes beginning collectors, scientists, divers, underwater photographers and dealers.

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**New taxa published in The Festivus in 2021:** *Cassis rasae* Petuch and Berschauer, 2021; *Cassis viliusi* Petuch and Berschauer, 2021; *Malea hyaducki* Petuch and Berschauer, 2021; *Floraconus (Sciteconus) mosterti* R. Aiken, 2021; *Floraconus (Sciteconus) markpagei* R. Aiken, 2021; *Neostrombini* Liverani, Dekkers & Maxwell, 2021; *Canarium (Comundrum)* Liverani, Dekkers & Maxwell, 2021; *Canarium (Elegantum)* Liverani, Dekkers & Maxwell, 2021; *Canarium (Stereostrombus)* Liverani, Dekkers & Maxwell, 2021; *Maculastrombus* Liverani, Dekkers & Maxwell, 2021; *Neostrombus* Liverani, Dekkers & Maxwell, 2021; *Neostrombinae* Maxwell & Rymer, 2021; *Neoaligerinae* Maxwell & Rymer, 2021; *Scaphella kendrae* Petuch and Berschauer, 2021; *Volutifusus doughtsheltoni* Petuch and Berschauer, 2021; *Volutifusus kissimmeensis* Petuch and Berschauer, 2021; *Jaspidiconus vanini*, Crabos, Oliveira, Almeida, & Queiroz, 2021; *Jaspidiconus tinharensis*, Crabos, Oliveira, Almeida, & Queiroz, 2021; *Barycypraea abbasi*, Dovesi and Parsons, 2021; *Barycypraea alessandrovesi*, Dovesi, 2021; *Quasimitra houarti* Dharma, 2021; *Ophiglossolambis itsumiae* Lum, 2021; *Marginella (Nataliamarginella) mbaseensis* S.G. Veldsman, 2021; *Marginella (Nataliamarginella) mtataensis* S.G. Veldsman, 2021; *Marginella (Nataliamarginella) mlambomkuluensis* S.G. Veldsman, 2021; *Marginella (Nataliamarginella) muratovi* S.G. Veldsman, 2021; *Marginella (Punctamarginella) transovula* S.G. Veldsman, 2021; *Amphidromus davidberschaueri* Thach, 2021; *Nannamoria flindersi* Hawke, 2021; *Nannamoria costatum* Hawke, 2021; *Nannamoria gnotuki* Hawke, 2021; *Nannamoria alquezae* Hawke, 2021; *Nannamoria malonei* Hawke, 2021; *Nannamoria cadella* Hawke, 2021; *Nannamoria hiscocki* Hawke, 2021; *Nannamoria persimilis* Hawke, 2021; *Angaria stevenliei* Parsons & Abbas, 2021; *Canarium (Canarium) darwinense* Maxwell & Dekkers, 2021; *Canarium (Canarium) nipponium* Maxwell & Dekkers, 2021; *Amphidromus dancei* Dharma, 2021; *Amphidromus felixi* Dharma, 2021; *Amphidromus (Syndromus) porcellanus gistingensis* Dharma, 2021; *Amphidromus ubaldii* Dharma, 2021.



## New Species of *Nannamoria* from the Pliocene and Miocene of Australia (Caenogastropoda: Volutidae)

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**ABSTRACT** This study provides the taxonomic description of eight species of *Nannamoria* Iredale, 1929 from Miocene deposits of Victoria and South Australia and Pliocene deposits of Flinders Island Tasmania, Australia. The following new species are described, discussed and compared to their congeners: *Nannamoria costatum* n. sp., *Nannamoria flindersi* n. sp., *Nannamoria hiscocki* n. sp., *Nannamoria gnotuki* n. sp., *Nannamoria alquezae* n. sp., *Nannamoria cadella* n. sp., *Nannamoria malonei* n. sp. and *Nannamoria persimilis* n. sp. Various aspects of *Nannamoria* evolution are discussed.

**KEYWORDS** Mollusca, Gastropoda, Volutidae, *Nannamoria*, fossil, palaeontology, new species, Australia, Victoria, South Australia, Tasmania, *N. costatum*, *N. flindersi*, *N. hiscocki*, *N. gnotuki*, *N. alquezae*, *N. cadella*, *N. malonei*, *N. persimilis*

### INTRODUCTION

*Nannamoria* Iredale, 1929 is a genus of predatory marine gastropods belonging to the family Volutidae. They are endemic to Australia and are typically found in deep water in sandy environments. Their shells are generally quite small (20-50 mm) with a short conical spire and multispiral protoconch, which is dome-like or pupiform in shape. The shoulder usually bears nodules or sharply pointed spines and the columella usually has four strong plaits. *Nannamoria* species have an extensive fossil history in southern Australia and first appeared in the early Miocene, although in Darragh's (1988) revision of Tertiary Volutidae of South-Eastern Australia, he states that the oldest species in the genus is *N. weldii* from the upper Oligocene beds of Victoria. However, *N. weldii* appears to be restricted to the early Miocene, suggesting a possible error. This is likely attributed to specimens similar to *A. weldii* from the lower Miocene beds of Torquay being mixed-up with the upper Oligocene beds below.

Fossil records indicate that *Nannamoria* experienced a period of radiation during the early Miocene like many other endemic genera of marine gastropods from South Eastern Australia, although the paleoenvironmental reasons for this radiation are uncertain (personal observation). The extinct species reached their peak diversity during the Middle Miocene, when the earth's temperature was considerably warmer than it is today.

There are currently eight extant species in the genus, *N. amacula* Iredale, 1929; *N. brevisforma* Bail & Limpus, 2008; *N. bulbosa* Bail & Limpus, 2008; *N. gotoi* Poppe, 1992; *N. inflata* Bail & Limpus, 2008; *N. inopinata* Darragh, 1979; *N. parabola* Garrard, 1960 and *N. ranya* Willan, 1995. The fossil record contains twelve species: *N. ralphi* (Filay, 1930); *N. weldii* (Tenison Woods, 1876); *N. limbata* (Tate, 1888); *N. lundeliusae* Ludbrook, 1978; *N. trionyma* Darragh, 1989; *N. stolidia* (Johnson, 1888); *N. strophodon* (McCoy, 1876); *N. paraboloides* Darragh, 1989; *N. fasciculata* Darragh 1989; *N.*



*deplexa* Darragh, 1989; *N. cinctuta* Darragh 1989; and *N. amplexa* Darragh 1989. This study describes an additional eight species of fossil *Nannamoria*.

Fossil records are known from the Bass, Otway, Gippsland and Murray basins of Victoria and South Australia and extant species only occur in eastern Australian overlap (personal observation). It is possible however, that the genus *Paramoria* (Smith, 1886) also belongs to the genus *Nannamoria*, as some species can be readily placed in either genera and this would indicate a much wider distribution. The morphologies of the new species described in this paper differ from those of known species and these differences are discussed, along various aspects of *Nannamoria* evolution.

### Abbreviations.

MV = Museum of Victoria, Melbourne

CAH = Collection of Angus Hawke, Melbourne

### MATERIALS AND METHODS

The author has examined numerous specimens in museums and private collections in Victoria, New South Wales and South Australia. Additional material was obtained from field research during 2009-2020. In some cases, only a few specimens were available for study. Mature, adult specimens were used for morphometric analysis and to evaluate key characteristics. The following measurements were taken: shell length, width, height and the number of shoulder nodules or spines has been counted for some of the species. In the absence of soft-bodied anatomical characters, molecular data and colour pigmentation, this taxonomic study is primarily based on three types of evidence. These are: a) morphological (*i.e.*, what characters can be used to differentiate between distinct taxa); b) spatial (*i.e.*, to what extent does the geography influence

evolutionary relationships); and c), temporal (*i.e.*, to what extent can supposed age differences between deposits inform evolutionary changes). All these lines of evidence were considered *a priori* to the taxonomic decisions made.

### SYSTEMATICS

Superfamily : Volutoidea Rafinesque, 1815  
Family : Volutidae Rafinesque, 1815  
Genus : *Nannamoria* Iredale, 1929  
Type species : *Nannamoria amicula* Iredale, 1929 (original designation)

*Nannamoria flindersi* Hawke, new species  
(Plate 2, Figures 1-14; Plate 5, Figure 2)



**Holotype:** Plate 2, Figures 2a, 2b. MV - P344175.

**Description.** Solid shell, ranging from 25 to 30mm in length; shape somewhat biconic, tapering to narrow anterior end; protoconch with three tumid whorls; moderately short, to short pointed spire; strong prominent sculpture, consisting of approximately 14-16, narrowly spaced axial costae on outer whorl, extending full length of shell; shoulder bearing prominent pointed nodules, which grade into the axial costae of the whorls; outer lip smooth, moderately thickened with slight outward flare; columella with four strong plaits.



**Type Material.**

Holotype: (Plate 2, Figures 2a, 2b) 29.6 mm (L) 20.7 mm (W) Type locality. MV P344175

Paratype: 1 (Plate 2, Figures 4a, 4b) 26.6 mm (L) 17.4 mm (W) 13.3 mm (H) Type locality.

Paratype: 2 (Not illustrated) 28.5 mm (L) 19.0 mm (W) 19.3 mm (H) Type locality.

Paratype: 3 (Plate 2, Figures 6a, 6b) 27.8 mm (L) 15.3 mm (W) 13.5 mm (H) Coll: Paul Southgate

Paratype: 4 (Plate 2, Figures 1a, 1b) 29.4 mm (L) 16.8 mm (W) 13.3 mm (H) Type locality.

Paratype: 5 (Plate 2, Figures 5a, 5b) 25.6 mm (L) 14.2 mm (W) 12.0 mm (H) Type locality.

Paratype: 6 (Plate 2, Figures 7a, 7b) 29.8 mm (L) 18.3 mm (W) 13.2 mm (H) Type locality. CAH

Paratype: 7 (Plate 2, Figures 9a, 9b) 28.4 mm (L) 15.5 mm (W) 13.3 mm (H) Type locality.

Paratype: 8 (Plate 2, Figures 11a, 11b) 30.3 mm (L) 17.1 mm (W) 14.9 mm (H) Type locality.

Paratype: 9 (Plate 2, Figures 13a, 13b) 27.2 mm (L) 17.1 mm (W) 13.3 mm (H) Type locality.

Paratype: 10 (Plate 2, Figures 14a, 14b) 30.3 mm (L) 18.3 mm (W) 19.7 mm (H) Type locality.

Paratype: 11 (Plate 2, Figures 12a, 12b) 28.7 mm (L) 16.8 mm (W) 14.2 mm (H) Type locality.

Paratype: 12 (Plate 2, Figures 10a, 10b) 26.6 mm (L) 16.0 mm (W) 13.3 mm (H) Type locality.

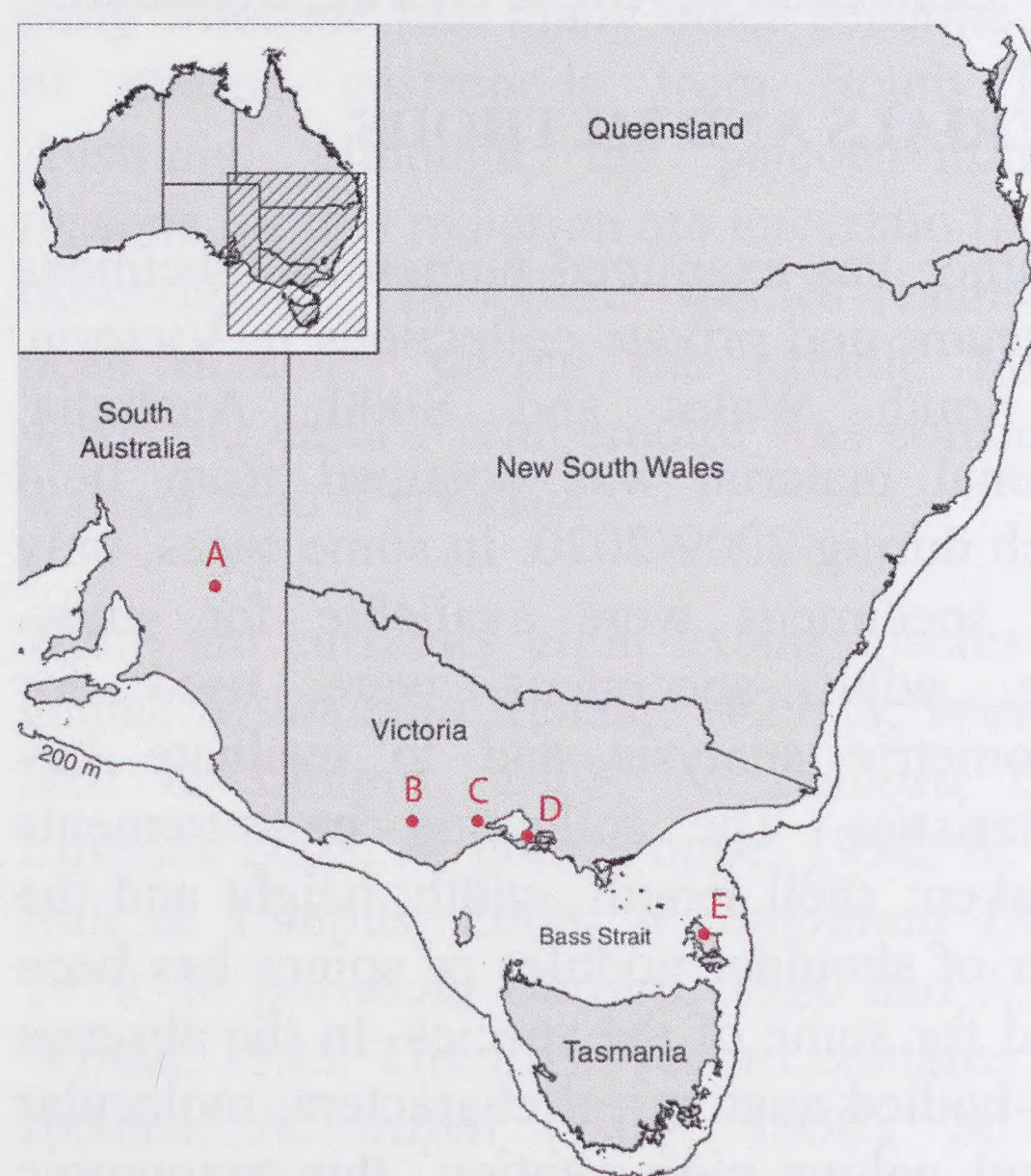
Paratype: 13 (Plate 2, Figures 8a, 8b) 26.4 mm (L) 16.4 mm (W) 13.4 mm (H) Type locality.

Paratype: 14 (Plate 2, Figures 3a, 3b) 27.7 mm (L) 16.3 mm (W) 13.3 mm (H) Type locality.

**Type Locality/Distribution.** Known only from the Pliocene deposits of the Cameron Inlet Formation on Flinders Island, restricted to only a few locations (Refer to Map 1).

**Etymology.** Named in honour of Matthew Flinders, after which Flinders Island, Tasmania is named.

**Remarks.** This species has been treated as a variant of *N. paraboloides* in the past, (see Goudey, 2018: Page 33, fig. G). although it differs from that species by way of the prominent axial costae. The author has not found the two species in the same area, suggesting they may not have been sympatric, although more fieldwork is needed to confirm. *Nannamoria paraboloides* is the most abundant *Nannamoria* species from Flinders Island, although well-preserved specimens are rare. The pattern is quite often well preserved and comparable to that of other extinct *Nannamoria*. For example, the pattern of *N. malonei* n. sp (described herein) has been revealed using ultraviolet light, which causes the pigmented regions of the shell to fluoresce and this examination has shown similar patterns in both species with some subtle differences. The pattern is also similar to that in a number of *Notovoluta* species; both fossil and extant.



**Map 1.** (A) Morgan, South Australia (B) Lake Gnotuk, Victoria. (C) Batesford Quarry, Victoria, (D) Gunyoung Creek, Victoria, (E) Cameron Inlet Formation, Flinders Island, Tasmania.



*Nannamoria costatum* Hawke, new species  
(Plate 4, Figures 1a, 1b; Plate 5, Figure 7)



**Holotype:** Plate 4, Figures 1a, 1b. MV - P344171.

**Description.** Solid shell, ranging from 35 to 50 mm in length; shape biconic to subcylindrical, tapering to narrow anterior end; slightly convex protoconch with three whorls; moderately high spire; poorly developed sculpture, consisting of approximately 25-32, narrowly spaced axial costae on outer whorl, extending full length of shell; outer lip is smooth, slightly thickened, columella with four strong plaits.

**Type Material.** Holotype: From type locality (Plate 4, Figures 1a, 1b) 37.6 mm (L) 20.4 mm (W) MV - P344171.

**Distribution.** Known only from the Pliocene deposits of the Cameron Inlet formation on Flinders Island, Tasmania, where it is restricted to only a few locations (Refer to Map 1).

**Etymology.** Costatum = Latin for 'ribbed', referring to the numerous distinctive ribs that distinguish this species.

**Remarks.** This species superficially resembles other species of *Nannamoria* from Flinders

Island, although it is very distinctive and cannot be confused with other species. *Nannamoria costatum* n. sp. is quite large for the genus and fairly rare. The conical spire and small protoconch are characteristic of *Nannamoria*. Other specimens of this species were examined by the author but were unable to be included.

*Nannamoria gnotuki* Hawke, new species  
(Plate 1, Figures 3a, 3b; Plate 5, Figure 1)



**Holotype:** Plate 1, Figures 3a, 3b. MV - P344173.

**Description.** Solid shell, ranging from 30 to 35 mm in length; shape pyriform, tapering to narrow anterior end; protoconch with three tumid whorls; short, rounded, squat spire; shoulder bearing narrowly spaced, pointed nodules, drawn out into flange or triangular plates; shoulder nodules sometimes form slight axial costae, which taper-out towards anterior end; outer lip smooth, slightly thickened, with minor inward flare; columella with four strong plaits.

**Type Material.**

Holotype: (Plate 1, Figures 3a, 3b) 30.3 mm (L) 20.9 mm (W) Type locality. MV - P344173.

Paratype 1: (Plate 1, Figures 5a, 5b) 21.8 mm (L) 19.3 mm (W) Type locality. MV - P344174.



Paratype 2: (Plate 1, Figures 1a, 1b) 33.0 mm (L) 21.5 mm (W) 18.8 mm (H) Type locality. CAH.

**Distribution.** Known only from Lake Gnotuk, Victoria, which is the type location (Refer to Map 1).

**Etymology.** Named after the type location, Lake Gnotuk, Victoria, Australia.

**Remarks.** The key characteristic of this species is the narrowly spaced shoulder nodules, which in most specimens are drawn out into flange-like plates. The shape of the spire and spacing of the shoulder nodules, indicate that this species is possibly ancestral *N. amplexa* and the most likely predecessor is *N. strophodon*. Most specimens are slightly eroded. Only known from type location.

*Nannamoria alquezae* Hawke, new species  
(Plate 4, Figures 6a, 6b; Plate 5, Figure 3)



Holotype: Plate 4, Figures 6a, 6b. MV - P344178.

**Description.** Shell ranging from 35 to 45 mm in length; somewhat biconic to elongate in shape, tapering to narrow anterior end; protoconch with three whorls; high spire; shoulder smooth or bearing weak to moderate subspinose nodules; shoulder nodules usually absent in early whorls;

lacks axial costae or prominent sculpture; columella with four strong plaits.

#### Type Material.

Holotype: (Plate 4, Figures 6a, 6b) 32.8 mm (L) 15.4 mm (W) Type locality. MV - P344178.

Paratype: 1 (Plate 4, Figures 11a, 11b) 31.4 mm (L) 15.0 mm (W) Type locality. MV - P344180.

Paratype: 2 (Plate 4, Figures 7a, 7b) 40.3 mm (L) 17.5 mm (W) 17.3 mm (H) Type locality CAH.

Paratype: 3 (Plate 4, Figures 9a, 9b) 40.7 mm (L) 18.3 mm (W) 16.4 mm (H) Type locality.

Paratype: 4 (Plate 4, Figures 12a, 12b) 33.3 mm (L) 14.4 mm (W) 13.4 mm (H) Type locality.

Paratype: 5 (Plate 4, Figures 8a, 8b) 35.8 mm (L) 16.8 mm (W) 15.2 mm (H) Type locality.

Paratype: 6 (Plate 4, Figures 10a, 10b) 40.1 mm (L) 18.4 mm (W) 17.6 mm (H) Type locality.

Paratype: 7 (Plate 4, Figures 13a, 13b) 36.2 mm (L) 16.4 mm (W) 14.0 mm (H) Type locality.

Paratype: 8 (Plate 4, Figures 5a, 5b) 28.6 mm (L) 14.6 mm (W) 12.4 mm (H) Type locality,

**Distribution.** Found in several localities of Bairnsdalian age, which is Middle Miocene. The type location is Gunyoung Creek on the Mornington Peninsula, Victoria, Australia.

**Etymology.** Named in honour of Apple Alqueza, who has often provided extensive assistance in the field.

**Remarks.** Darragh illustrated *Nannamoria alquezae* n. sp. under the name *N. limbata* in his (1988) revision of Tertiary Volutidae of South-Eastern Australia (Page 284, fig. 9). However, Darragh's specimen differs from the latter by way of the higher spire, more biconical shape, as well as being slightly less robust. The two species appear to be closely related and occur in the same deposits at a number of locations suggesting they were sympatric, although not all sites appear to have both species. *Nannamoria alquezae* n. sp. superficially resembles



*Notovoluta differta*, Darragh, 1989, although that species is only found in lower Miocene deposits and lacks shoulder nodules. *N. alquezae* does not exhibit decortication of the suture of the suture, as seen in *N. limbata*.

*Nannamoria malonei* Hawke, new species  
(Plate 3, Figures 1a, 1b; Plate 5, Figure 8)



**Holotype:** Plate 3, Figures 1a, 1b. MV - P344169.

**Description.** Solid shell, ranging from 35 to 45 mm in length; shape biconic to obovate; tapering to narrow anterior end; protoconch with three whorls; moderately short rounded spire, strong prominent shoulder nodules, consisting of approximately 7 to 8 broadly spaced nodules on outer whorl, outer lip is smooth, moderately thickened; columella with four strong plaits.

#### Type Material.

**Holotype:** (Plate 3, Figures 1a, 1b) 41.5 mm (L) 21.4 mm (W) Type locality. MV - P344169.

**Paratype 1:** (Plate 3, Figures 2a, 2b) 39.3 mm (L) 22.4 mm (W) 21.4 mm (H) Type locality. CAH.

**Paratype 2:** (Plate 3, Figures 3a, 3b) 37.6 mm (L) 21.3 mm (W) 20.2 mm (H) Type locality. CAH.

**Paratype 3:** (Plate 3, Figures 4a, 4b) 41.3 mm (L) 23.2 mm (W) 22.5 mm (H) Type locality.

**Paratype 4:** (Plate 3, Figures 5a, 5b) 36.7 mm (L) 20.5 mm (W) 19.5 mm (H) Type locality.

**Paratype 5:** (Plate 3, Figures 6a, 6b) 38.0 mm (L) 20.6 mm (W) 20.8 mm (H) Type locality.

**Paratype 6:** (Plate 3, Figures 7a, 7b) 33.9 mm (L) 19.6 mm (W) 28.5 mm (H) Type locality.

**Paratype 7:** (Plate 3, Figures 8a, 8b) 40.4 mm (L) 21.5 mm (W) 21.0 mm (H) Type locality.

**Distribution.** Most specimens originate from Batesford Quarry in Victoria, Australia, where the type material has been collected. This species also occurs at Fossil Beach, in Victoria, Australia, although it is very rare at this location (Refer to Map 1).

**Etymology.** Named in honour of Mark Malone, who has provided specimens and supported my fieldwork.

**Remarks.** This species is most similar to *N. trionyma*, although it differs by way of its larger size, more rounded spire, larger protoconch and stronger shoulder nodules, which are less numerous. *Nannamoria malonei* n. sp. typically has between 7 and 8 shoulder nodules, with an average of 7.8 among the type material, whereas *N. trionyma* typically has between 8 and 13 shoulder nodules, with an average of 10.5. *N. trionyma*, is also a much more variable species. *Nannamoria malonei* n. sp. most likely evolved from *N. persimilis* n. sp. and is found alongside *N. strophodon*, although it can be readily separated from *N. strophodon* by its more robust shell, rounded protoconch and the sharp triangular shoulder nodules. It has a restricted range and most examples are from Batesford Quarry, Victoria.



*Nannamoria cadella* Hawke, new species  
(Plate 1, Figures 10a, 10b; Plate 5, Figure 4)



**Holotype:** Plate 1, Figures 10a, 10b. MV - P344168.

**Description.** Solid shell, ranging from 20 to 30mm in length; shape, cylindrical to obovate, tapering to narrow anterior end; small round protoconch with three whorls; short to moderate spire; weak shoulder nodules, consisting of approximately 5 to 7 broadly spaced nodules on outer whorl; outer lip thin and typically looks immature; columella with four strong plaits; indistinct siphonal notch.

**Type Material.**

Holotype: (Plate 1, Figures 10a, 10 b) 21 mm (L) 13.3 mm (W) Type locality. MV - P344168.  
Paratype 1: (Plate 1, Figures 8a, 8b) 27 mm (L) 12.7 mm (W) 12.4 mm (H) Type locality. CAH.  
Paratype 2: (Plate 1, Figures 7a, 7b) 26.3 mm (L) 22.7 mm (W) 11.5 mm (H) Type locality.  
Paratype 3: (Plate 1, Figures 9a, 9b) 23.4 mm (L) 13.3 mm (W) 12.7 mm (H) Type locality.

**Distribution.** Known only from the Cadel Formation, 4.8km south of Morgan-Cadell Rd, South Australia (Refer to Map 1).

**Etymology.** Named after the Cadel Formation.

**Remarks.** This Middle Miocene species is similar to *N. trionyma*, although it differs by way of its smaller size and more slender, cylindrical shape. It also has less developed shoulder nodules, which are less numerous. *Nannamoria cadella* n. sp. typically has between 5 and 7 shoulder nodules, with an average of 6.4. Whereas, *N. trionyma*, typically has between 8 and 13 shoulder nodules, with an average of 10.5 (Hawke, unpublished data). The unique features are very apparent when compared side by side (see Table 1).

|                                | <i>N. trionyma</i>                                                 | <i>N. malonei</i>                                              | <i>N. cadella</i>                                              |
|--------------------------------|--------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------|
| Typical Size (mm)              | 25 to 35                                                           | 35 to 45                                                       | 20 to 30                                                       |
| Shape                          | biconic to obovate                                                 | biconic to obovate                                             | cylindrical to obovate                                         |
| Spire                          | moderately short, somewhat pointed                                 | moderately short rounded                                       | moderately short bullet shaped                                 |
| Expression of shoulder nodules | weak to moderate shoulder nodules                                  | strong prominent shoulder nodules                              | weak shoulder nodules                                          |
| Number of shoulder nodules     | approximately 8 to 13 moderately spaced nodules on the outer whorl | approximately 7 to 8 broadly spaced nodules on the outer whorl | approximately 5 to 7 broadly spaced nodules on the outer whorl |

**Table 1.** Comparison of *Nannamoria trionyma*, *N. malonei* n. sp and *N. cadella* n. sp.



*Nannamoria hiscocki* Hawke, new species  
(Plate 4, Figures 3a, 3b; Plate 5, Figure 5)



**Holotype:** Plate 4, Figures 3a, 3b. MV - P344170.

**Description.** Solid shell, ranging from 35 to 40 mm in length; shape somewhat biconic to pyriform, tapering to narrow anterior end; protoconch with three tumid whorls; short, rounded, subconical spire; moderate sculpture, consisting of approximately 14-16, narrowly spaced axial costae on outer whorl, extending full length of the shell; shoulder bearing prominent pointed nodules, which grade into axial costae of whorls; outer lip smooth, moderately thickened with slight flare. columella with four strong plaits.

#### **Type Material.**

Holotype: (Plate 4, Figures 3a, 3b) 36 mm (L) 22.7 mm (W) Type locality. MV - P344170.

Paratype 1: (Plate 4, Figures 4a, 4b) 32.8 mm (L) 19.6 mm (W) 13.5 mm (H) Coll: Paul Southgate.

**Distribution.** Known only from the Pliocene deposits of the Cameron Inlet formation on Flinders Island, Tasmania. Restricted to a few locations (Refer to Map 1).

**Etymology.** Named in honour Dr. Martin Hiscock, from Melbourne Australia, who has shown a great deal of kindness over the years and assisted in obtaining specimens for my research.

**Remarks.** This species closely resembles *Mauithoe insignis* (Marwick, 1926) from the Miocene of New Zealand and it is possible there is a close association between the two species from an evolutionary perspective, especially given the similarity in fauna between Australia and New Zealand. Beu and Maxwell (1990) stated that *M. insignis* has five strong columella plaits, although all the specimens examined by the author have four, which is consistent with *Nannamoria*. Further investigation is needed to establish the relationship between *Mauithoe* and *Nannamoria*. The taxa found in association with this species suggests it is slightly older than *N. flindersi* n. sp, and if this is the case, then it is possible that this species gave rise to *N. flindersi*. n. sp.

*Nannamoria persimilis* Hawke, new species  
(Plate 1, Figures 2a, 2b; Plate 5, Figure 6)



**Holotype:** Plate 1, Figures 2a, 2b. MV - P344172.



**Description.** Solid shell, ranging from 40 to 45 mm in length; shape biconic to obovate, tapering to narrow anterior end; large round protoconch with three whorls; high pointed spire, strong prominent shoulder nodules, consisting of approximately 7 to 8 broadly spaced nodules on outer whorl; outer lip smooth, moderately thickened; columella with four strong plaits.

#### **Type Material.**

Holotype: (Plate 1, Figures 2a, 2b) 39.8 mm (L) 20 mm (W) Type locality. MV - P344172.

Paratype 1: (Plate 1, Figures 4a, 4b) 42.5 mm (L) 22.7 mm (W) 19.2 mm (H) Type locality. CAH.

Paratype 2: (Plate 1, Figures 6a, 6b) 39.4 mm (L) 19.1 mm (W) 18.9 mm (H) Type locality. CAH.

**Distribution.** Known only from the type location, which is the lower Miocene beds of Jan Juc beach.

**Etymology.** Persimilis = Latin for 'very like' in reference to the similarities to *N. weldii*.

**Remarks.** This species is quite similar to *N. weldii*, which is highly variable and may be represented by more than one species, although more research is needed to determine if this is the case. *Nannamoria persimilis* n. sp. is much less variable and there are a few key differences. For example, *N. persimilis* n. sp. is generally more elongated, with a larger protoconch and has stronger shoulder nodules, when compared to specimens of *N. weldii* with a similar shape. *Nannamoria weldii* is usually wider with a smaller protoconch. *Nannamoria persimilis* n. sp. also bears some resemblance with *N. strophodon*, although the two species are very different and can easily be separated by the taller spire and sharper shoulder nodules. *Nannamoria malonei* n. sp. has a larger, more rounded protoconch, stronger shoulder nodules, heavier shell and usually has 2 to 3 less

shoulder nodules. *Nannamoria persimilis* n. sp. is possibly ancestral to *N. malonei* n. sp., by way of flattening of the spire and inflation of the shoulder width.

#### **DISCUSSION**

The close relationship between *Nannamoria*, *Amoria*, *Paramoria* and *Notovoluta* is quite apparent and at times they can be hard to differentiate. For example, the morphology and preserved pigmentation in *N. lundeliusae* clearly indicate that the closest relative is *Paramoria johnclarki* Bail & Limpus, 1997. If this is the case, then maybe *N. lundeliusae* should be reassigned to *Paramoria* or perhaps *Paramoria* should be lumped with *Nannamoria* and in the opinion of the author, *Paramoria* should never have been reinstated. Darragh (1988) stated that species such as *N. weldii* can be readily placed in either *Paramoria* or *Nannamoria* as defined and preferred to regard the two taxa as synonyms until further anatomical work proves otherwise, with which this author agrees. Unfortunately, the proclivities of taxonomic splitting in recent times have become a contentious issue and often a valid, monophyletic genus has been split into many smaller genera, without fixing any phylogenetic problems with existing taxon. Darragh examined the radula of *N. amacula* and noted that it was similar to that of *Paramoria guntheri* and many other *Amoria*. He also stated that the anatomical morphology was similar, except that the radula was unicuspid (Darragh, 1988).

#### **Climatic and biostratigraphy of Nannamoria.**

Paleoclimatic variability has played a large role in shaping the endemic fauna we find in Australia today. Approximately 14.5 million years ago the earth's temperature steadily began to cool, which caused many land and marine species to go extinct. (Sterling 2011) This event is known as the Middle Miocene Disruption and



it triggered a shift in the position of the overlap zones, between the tropical and temperate regions. It is probably the cause for the reduction of many of the endemic taxa of that time, including *Nannamoria*. Many of the lineages, which have survived until the present-day, appear to have either migrated north-east, or west, where the water temperature is slightly warmer (personal observation). Today, there are no species of *Nannamoria* that inhabit the waters of Victoria and Tasmania, where a myriad species once flourished. The most likely reason for this is a Paleoclimatic change, which seems to have pushed many of the species into warmer waters of South Western Australia and particularly towards Northern NSW and southern Queensland. In fact, many endemic species from northern NSW and southern Queensland resemble species that once lived in south-eastern Australia. Below are some examples of extinct taxa and their modern-day counterparts, which are now confined to northern NSW and southern Queensland (see Table 2).

| Fossil Species                                  | Extant species                                |
|-------------------------------------------------|-----------------------------------------------|
| <i>Ericusa ancillodes</i> †<br>(Tate, 1889)     | <i>Ericusa sericata</i><br>Thornley, 1951     |
| <i>Athleta antipinosa</i> †<br>(Tate, 1889)     | <i>Athleta studeri</i><br>(von Martens, 1897) |
| <i>Nannamoria strophodon</i> †<br>(McCoy, 1876) | <i>Nannamoria parabola</i><br>Garrard, 1960   |
| <i>Athleta bungae</i> †<br>Darragh 1971         | <i>Athleta insperata</i><br>Darragh 1979      |
| <i>Nannamoria limbata</i> †<br>(Tate, 1888)     | <i>Nannamoria inopinata</i><br>Darragh 1979   |

Table 2. Extinct taxa and their modern-day counterparts.

Ocean temperature is considered to be one of the most important physical factors affecting the distribution of molluscs and also has a substantial impact on the rate of extinction and evolution. Fossil records in south eastern Australia indicate that evolutionary changes in *Nannamoria* appear to occur more rapidly, when compared to other genera and very few species seem to be long-lasting. Changes in shell morphology can also be quite considerable over a relatively short period of time and this can be seen in some of the species from Flinders Island, which have experienced species radiation as a result of changing ocean temperatures and sea levels. There is substantial evidence showing that sea-levels fluctuated throughout the last ice age and during parts of the Pliocene. The oceans were 20-30 m higher than they are today. As a result, much of the eastern side of Flinders Island was covered by water, which is why there are fossils found on this part of the island. By comparing the habitat of a variety genera that have modern counterparts today, we can surmise that the species of *Nannamoria*, which are found at Flinders Island today would have likely lived in depths below 30 m (personal observation). The assemblages of species can also change quite significantly from one location to another on Flinders Island, despite locations being in relatively close proximity. There are a couple of conceivable ways to interpret this. One could be that the water gradually receded over an extended period of time, allowing the species in this region to evolve slightly or that there is stratification of differing ages. It is possible to get a rudimentary understanding of the slight age differences of the fossil deposits, by looking at the percentage of recent species contained within, as well as the number of species that closely resemble living species. General observations indicate that the older deposits are less likely to contain species with living representatives or species, which closely



resemble extant species. However, different regions have undergone different physical changes and consequently, variation in the rate of extinction and changes in shell morphology must also be considered when applying this ratiocination. *Nannamoria flindersi* n. sp. is generally found at sites with a relatively high proportion of molluscan species that are still living today. In contrast, *N. costatum* is generally associated with fewer living species. This suggests an age difference between the deposits of these two species. Neither of these species have been recorded from the same collection site by the author, despite the collection sites for each species being only a short distance away. Only one or two species of *Nannamoria* appear to have coexisted within the Pliocene deposits of Flinders Island and these species are likely to have evolved into the array of fossil species found on the island today. In order to properly categorize species and determine their evolutionary relationships, it is essential to understand the fossil record. Unfortunately, not enough emphasis is put into research of fossil species, which are often overlooked in favour of their modern counterparts, although this is steadily changing.

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<https://doi.org/10.54173/F534245>





**Plate 1.** Figures 1, 3, 5 = *Nannamoria gnotuki* n. sp. (Holotype Figure 3, P344173); Figures 2, 4, 6 = *Nannamoria persimilis* n. sp. (Holotype Figure 2, P344172); Figures 7, 8, 9, 10 = *Nannamoria cadella* n. sp. (Holotype Figure 10, P344168).



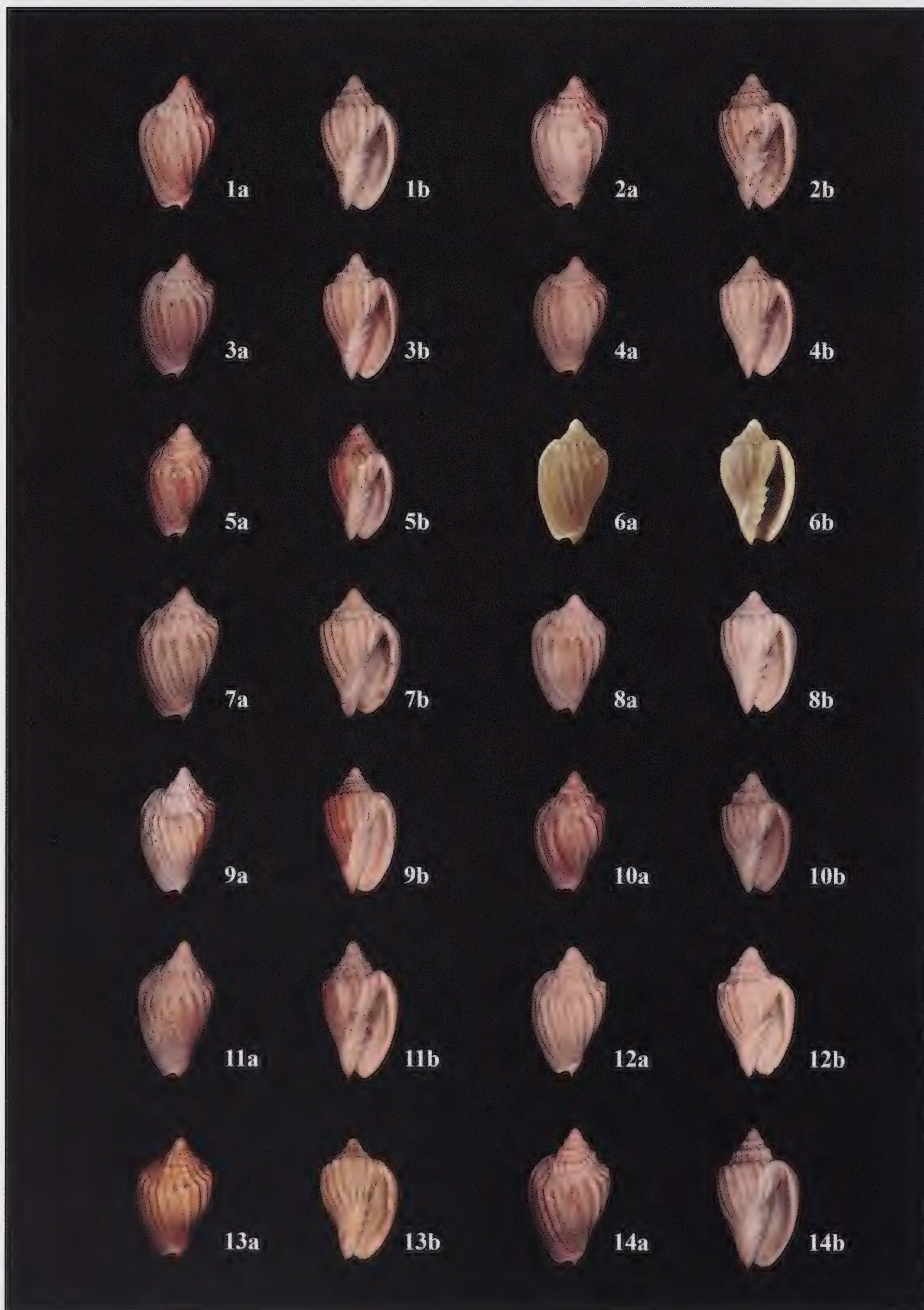


Plate 2. Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 = *Nannamoria flindersi* n. sp. (Holotype Figure 2, P344175).





Plate 3. Figures 1, 2, 3, 4, 5, 6, 7, 8 = *Nannamoria malonei* n. sp. (Holotype Figure 1, P344169).



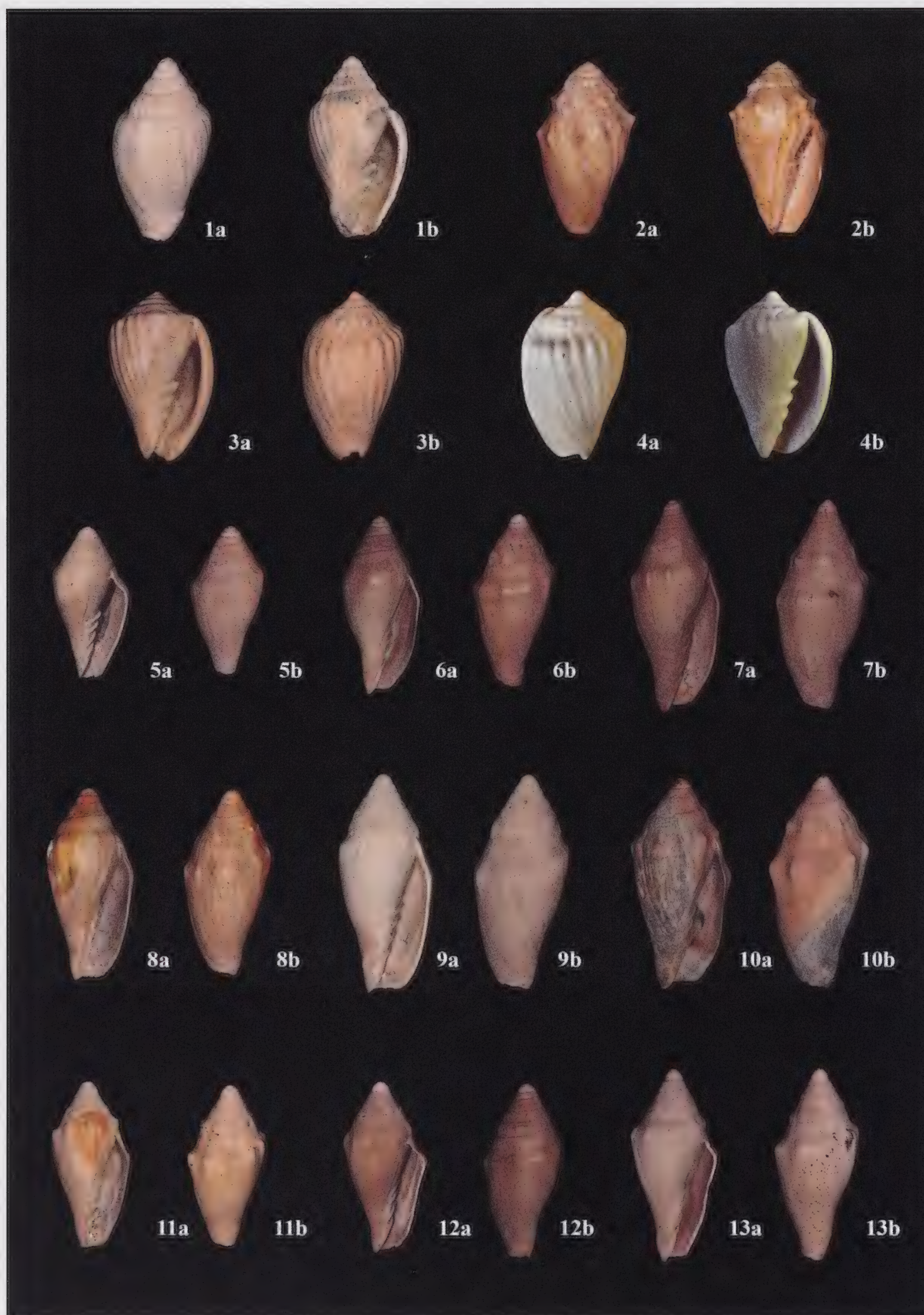


**Plate 4.** Figure 1 = *Nannamoria costatum* n. sp. (Holotype Figure 1, P344171); Figure 2 = *Nannamoria N. trionyma* (Included for reference); Figures 3, 4 = *Nannamoria hiscocki* n. sp. (Holotype Figure 1, P344170); Figures 5, 6, 7, 8, 9, 10, 11, 12, 13 = *Nannamoria alquezae* n. sp. (Holotype Figure 6, P344178).



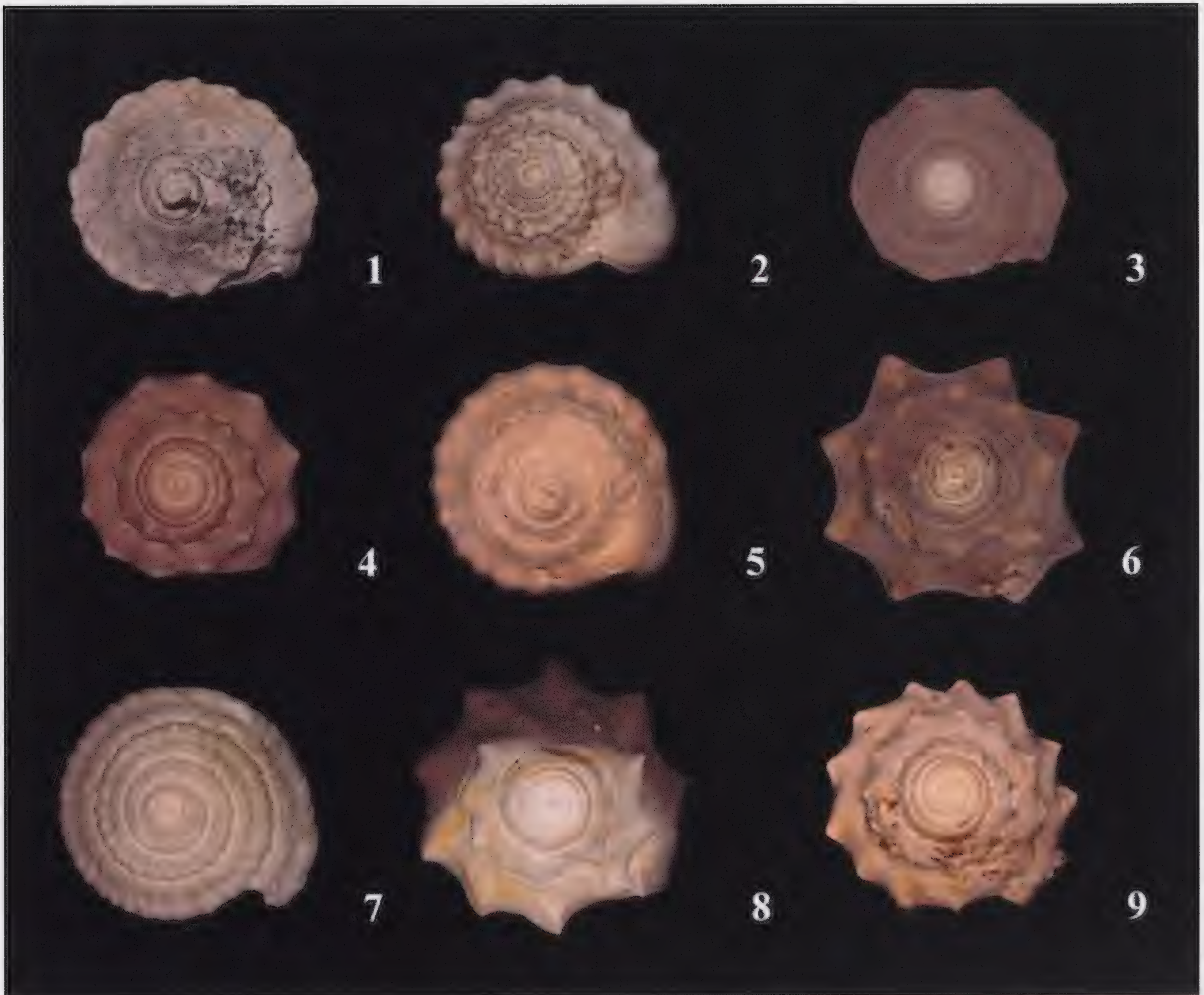


**Plate 5.** Figure 1 = *Nannamoria gnotuki* n. sp.; Figure 2 = *Nannamoria flindersi* n. sp.; Figure 3 = *Nannamoria alquezae* n. sp.; Figure 4 = *Nannamoria cadella* n. sp.; Figure 5 = *Nannamoria hiscocki* n. sp.; Figure 6 = *Nannamoria persimilis* n. sp. ; Figure 7 = *Nannamoria costatum* n. sp.; Figure 8 = *Nannamoria malonei* n. sp.; Figure 9 = *Nannamoria N. trionyma* (Included for reference).



## A New Species of *Angaria* Röding, 1798 (Gastropoda: Angariidae) from North-Western Sumbawa, Indonesia

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**ABSTRACT** This paper describes a new species of *Angaria* Röding, 1798 from north-western Sumbawa, Indonesia. In general appearance it resembles some forms of the species *Angaria delphinus* (Linnaeus, 1758) found in the same area and on neighbouring islands. The new species differs from it in sculptural features and interstitial markings, which it shares with two Vietnamese species, *Angaria fratummonsecourorum* Günther, 2013 and *Angaria guntheri* Thach, 2018.

**KEY WORDS** Angariidae, *Angaria*, *A. stevenliei*, new species, Sumbawa, Indonesia

### INTRODUCTION

Late in August of 2020, Steven Lie found a single curious specimen of *Angaria* Röding, 1798 among seashells he acquired from divers collecting off islands in the north-western part of Sumbawa, Indonesia. At first glance it appears to represent a new population of the nominate species *Angaria delphinus* (Linnaeus, 1758), found living in the same area and on neighbouring islands. However, a closer inspection shows it is a different species that displays a mix of features seen on *A. delphinus*, *A. guntheri* Thach, 2018 and *A. fratummonsecourorum* Günther, 2013. It is easily separable from *A. javanica* D. & K. Monsecour, 1999 of south-western Java. Because of the differences with the known species, it is described as a new species.

### MATERIALS AND METHODS

Shell dimensions were made in apertural view using digital Vernier callipers (rounded to 1 mm). Measurements excluding spines: shell height refers to the distance from top of spire to basal margin; and shell width (diameter) is the maximum distance between the median keel and posterior (or shoulder) keel at the aperture, measured along and perpendicular to the shell axis respectively. Measurements made in the same fashion except including spines are called “apparent shell height” and “apparent shell width” respectively. Shell sculpture was examined under low magnification (10x) using a jeweller's loupe and via digital images. Whorl count includes the apex (when visible) and counted to the nearest 0.125 (1/8) of a whorl; count is only approximate due to the apex and/or protoconch often being covered by encrustations or damaged.



**ABBREVIATIONS**

|         |                                                                                                                           |
|---------|---------------------------------------------------------------------------------------------------------------------------|
| LSL     | The Linnaean Shell Collection held at the Linnean Society of London, at Burlington House, Piccadilly, Mayfair, London, UK |
| MNHN    | Muséum national d'Histoire naturelle, Paris, France                                                                       |
| NBC     | Naturalis Biodiversity Center, Leiden, Netherlands                                                                        |
| SMNS    | Staatliches Museum für Naturkunde Stuttgart                                                                               |
| ZMA.MOL | NBC specimen label code, ex-Zoölogisch Museum Amsterdam (ZMA)                                                             |
| JP      | Jeff Parsons collection                                                                                                   |

This new species is described from a single empty shell, the holotype, obtained from local divers in north-western Sumbawa. Comparative material comprised of shells from the primary author's private collection, plus images of types and museum specimens. Photographic credits appear below the plates.

**Taxonomic remarks**

Dekker (2020) places the following species into synonymy with *Angaria nhatrangensis* Dekker, 2006:

*Angaria monsecourorum* Thach, 2016

*Angaria nasui* Thach, 2016

*Angaria monsecourorum* Thach, 2018

*Angaria kronenbergi* Thach, 2018

*Angaria petuchi* Thach, 2018

*Angaria walleri* Thach, 2018

Only *A. nasui* comes from a different locality: (Lý Sơn Island, Quảng Ngãi Province, Vietnam. All the others, including *A. nhatrangensis*, come from the Nha Trang area, Vietnam. Having not located any specimens collected in Indonesian waters that resemble *A. nhatrangensis*, it is not discussed in this paper.

**SYSTEMATICS**

Subclass: Vetigastropoda Salvini-Plawen, 1980

Order: Trochida Rafinesque, 1815

Superfamily: Trochoidea Rafinesque, 1815

Family: Angariidae Gray, 1857

Genus: *Angaria* Röding, 1798 (f.)

Type species: *Turbo delphinus* (m.) Linnaeus, 1758 (subsequent designation by P. Fischer, 1878)

*Angaria stevenliei* Parsons & Abbas,  
new species

(Plate 1, Figures 1-3 & Plate 3, Figures 19-21)

**Description.** Shell medium-sized, depressed turbate, thick, solid and translucent, except for subopaque interstitial markings and blackened spines. Spire very low, early whorls flattened and depressed, apex sunken. Suture impressed, undulated and margin distinctly lamellate (infrasutural cordlet). Whorls  $5\frac{1}{4}$ , descending in front; ultimate not inflated, upper part reclivous and steep at suture, flattened medially and subconvex below; tri-carinate, shoulder and basal (anterior) keels both strong, and a weaker medial keel. Sutural ramp of last whorl strongly corrugated by 9 wide, radial rugae; evenly positioned, each one thickened toward the base of a shoulder spine; furrows between them deep and darker. Rugae develop from nodules on the penultimate whorl, unevenly positioned until the last quarter whorl. Aperture of nearly equal height and width, sub-oblique laterally, opening circular and nacreous silver within; pentagonal in outline, base sub-effuse due to an open spine. Apertural border not stained by colour, and shows external markings on the crenulate palatal margin, matching the sculpture; its upper termination forms a shallow anal notch. Parietal area thick, columella narrow and oblique; and umbilicus wide, narrowly and deeply perforate at its centre. Umbilical tract spirally ridged



within, inner side finely lamellate and outer side partly spinose.

### Coloration and Pattern.

Early whorls pale primrose-yellow with a white spinose rim, apex rose; and antepenultimate whorl with a partial ruby red subsutural band. Penultimate whorl is ruby red with primrose-yellow nodules and rugae; and last whorl off-white from sutural ramp to outer edge of umbilical tract. Pattern consists of deep maroon markings (flecks, blotches or squiggles/zigzags) in the interspaces of the cordlets (fine spiral cords) and white growth threadlets, faded to carmine on the umbilical tract and basal keel. Markings extend as fused streaks onto the base of spines on shoulder and median keels. Differentiated circumumbilical zone absent; inner side of umbilical tract light buff with a ruby red border.

**Sculpture.** Spines on shoulder: moderately long, distorted and variably directed. Complete spines sub-ramose with wedge-shaped ends and curved trifurcate tips. Eight on last whorl, early ones ruby red and remainder blackish-purple; all flecked with off-white, sparse or obsolete on red ones; and final three project 10 to 12 mm outward. Seven on penultimate whorl, ruby red; and seven on antepenultimate whorl, the last two ruby red and the rest off-white. Spines on median keel: twelve on last whorl, base deltoid; ruby red becoming blackish-purple toward lip, all flecked with off-white; directed forward and downward or horizontal; last one c. 4 mm long. Twelve on penultimate whorl, those visible are ruby red. Spines on basal keel: pale orange-yellow, last one c. 2 mm long; bordered by two cordlets, appearing as lateral barbs in profile on final spine. Shoulder spines are hollow, (ignoring damage) most incompletely sealed at their leading edge, vs. lower spines not sealed and open (grooved).

Cordlets on last whorl: pale orange-yellow and positioned as follows. **A)** Eleven on sutural ramp, slightly paler on rugae, weaker in furrows and all squamulose, some obsolete or coarser. **B)** Five between shoulder and median keels, all squamulose. **C)** Nine between median and basal keels, three with very short spines (spinulose) [lowest one near basal keel] and others squamulose. Cordlets of **A)** to **C)** are inequidistant and sub-equal, some thinner or thicker than others and intersected by white growth threadlets, forming a reticulate pattern and same alignment weaker on sutural ramp. **D)** Six on the umbilical tract are unequal, where two pairs of fine, squamulose ones separate two wider spinulose ones and the basal keel.

**Type Material.** 1 adult shell, Holotype (MNHN-IM-2000-35827, Plate 1, Figures 1-3 and Plate 2, Figures 19-21) shell height 24 mm without spines vs. apparent shell height 27 mm with spines, shell width 28 mm without spines vs. apparent shell width 42 mm with spines, shell weight 8.25 g and 5.25 (5¼) whorls.

**Type Locality.** North-western Sumbawa, West Nusa Tenggara, Indonesia.

**Distribution.** Currently known only from the type locality.

**Ecology/Habitat.** Collected by local divers on fringing reef.

**Etymology.** Named in honour of Steven Lie for supplying the holotype.

### DIFFERENTIAL DIAGNOSIS

*Angaria delphinus* (Linnaeus, 1758) India to Philippines and south to Australia (Plate 1, Figures 4-5)



Similar in shape, solidity, apertural outline, lip thickness, some dimensions and in having shoulder spines recurved on spire whorls. Medial keel spines are similar, shorter or longer but never red. Differs from new species in lacking an infrasutural cordlet, instead has a “clear space” circa 3 mm wide; number of spines on shoulder less than on median keel (for example 7 versus 13); scales larger, subarcuate to tall-arched (vaulted) and cordlets coarser. Differently coloured post apical whorls, often greenish-yellow to yellowish-green, or pinkish; last whorl whitish becoming pink tinted to deep pink and a purple stained apertural border.

Pattern different, spirally lineate, white to pink cordlets with greyish or brown to black gemmae/granules, scales or spinules, and narrowing the spacing between them creates dark varieties where these may become solid-coloured lines; and interstitial markings absent. Shoulder spines are thick, rudely branched projections, very short or raised and divided into two or three lobes, or the tips shallowly to deeply lobed (laciniate); generally dark-coloured, sometimes red-lined on the back or rarely red on early whorls; always thicker, even when stunted and moderately- to widely-spaced. Basal keel spines not pale-coloured, equally fine on sympatric forms except forked; but generally larger, straight or forked, or short with tips shallowly lobed.

*Angaria javanica* K. & D. Monsecour, 1999  
SW Java, Indonesia (Plate 1, Figure 6)

Differs from new species in numerous ways, such as spire low to tall; suture deeply impressed and lacks a distinct infrasutural cordlet, occasionally bordered by a row of growth squamae; last whorl deeply descending in front, exposing the base of the penultimate whorl. Subaxial folds on sutural ramp angular in profile, curved or slanted forward and unevenly

positioned; wide and thickened toward suture; furrows shallow and paler than ridges; and often obsolescent toward lip. Aperture wider, width greater than height on specimen studied; and apertural border white edged with external coloration. Early whorls variable in colour, mainly white, red, green or black; surface and spines greyish brown or tinged with purple, which may be faded in places or lost on tips of spines; and shells lack a pattern.

Median and basal keels absent, basal slope rounded with 6 to 9 spinose cords and 3 or 4 spinose cords on outer side of the umbilical tract; spines erect or slightly recurved and scaly when not worn. Most spines are “hollow” and almost sealed, others are “open-sided”; sub-horizontal and laterally compressed on the shoulder with bifurcate tips; short below and of similar size, sub-horizontal above to erect or sub-recurved below. Underside surface is basically smooth between spines. Cordlets on sutural ramp and spines are scaly toward lip, both with arched or flattened scales respectively, which are crowded closer to lip, obsolete or absent (worn off) elsewhere.

*Angaria fratrummyonsecourorum* Günther,  
2013 Nha Trang, Khanh Hoa Province, Vietnam  
(Plate 2, Figures 10-12 and Plate 3, Figures 22-24)

Overall like an almost spineless version of the new species, being similar in shape, aperture and development of the posterior, median and basal keels. Spines have a similar “reddish” to “dark purplish” colour change, just different tones and hues. Differs in the colour of the infrasutural cordlet and other cordlets; and inner umbilical tract lacks a reddish border. Subaxial folds on sutural ramp similar on early whorls, except vinaceous-pink and become angular in profile, unevenly positioned on last whorl and obsolescent toward lip. Interstitial markings are



different, white and maroon on a claret brown ground and from a distance appear as purplish spiral bands speckled with white. According to Dekker (2020), *Angaria moolenbeeki* Thach, 2018 is a synonym.

***Angaria guntheri*** Thach, 2018 Nha Trang, Khanh Hoa Province, Vietnam (Plate 2, Figures 13-15 and Plate 3, Figures 25-27)

Somewhat resembles the new species, mostly in shape and having similar coloured cordlets and interstitial markings. Differs in all three keels being weaker; columella wider and thicker; aperture wider, width greater than height and outline elliptic-pentagonal; sutural ramp almost flat; and outer lip thinner, less mature than new species. It has a differently coloured penultimate whorl, whitish circumumbilical zone; narrower infrasutural cordlet; and radial rugae are not darkened or paler. Surface rougher, so pattern is more diffuse; markings appear similar, except above the base these are reddish (jasper red or maroon) and white on a paler reddish ground; base is white with reddish markings, which are sparse on the basal keel.

Spines slightly more numerous on shoulder and median keels and differently coloured; pinkish or reddish ones marked with white wiggly lines and macules. Spines on basal keel slightly darker, spines on the umbilical tract are larger; and scales present are thicker and/or larger. Sutural ramp corrugation is less pronounced and develops from twin-peaked nodes connected by cordlets on the penultimate whorl and furrows deep; nodes expand into angular radial ridges on the last whorl with outer peak larger, thickened medially and weakened (reduced) toward lip, and furrows shallow.

***Angaria cf. guntheri*** Thach, 2018 Moluccas (Maluku), Indonesia (Plate 2, Figures 7-9 and Plate 3, Figures 28-30)

Shell displays a mix of features seen on *Angaria guntheri* and the next species. It differs from the new species in having longer pale-coloured spines without forked tips, compressed towards the lip. Cordlets on upper surface off-white becoming cream-coloured adaperturally; those below the shoulder buff-pink and coarser, sub-medial ones have much longer spines. Sutural ramp somewhat flat with weaker radial rugae that are angular in profile, thickened medially, curved forward or perpendicular to suture and unevenly spaced, obsolescent toward lip; furrows shallow and darker than the rugae.

Spines from suture to anterior/basal keel are buff-pink to testaceous with off-white markings. Interstitial markings ox blood red to maroon and set between off-white growth threads, equally distinct above and below the shoulder; on upper surface coalescent toward the lip and at the base of shoulder spines, and absent below the basal keel. Inner umbilical tract dull rose pink and surrounded by fewer spinose cordlets. Medial and basal keels weakly developed, and shoulder keel moderately strong; outer umbilical tract with only two pale buff-pink, spinose cordlets. Aperture is wider, more rounded and sub-pentagonal in outline with a thinner outer lip.

***Angaria scalospinosa*** Günther, 2016 Masbate, Philippines (Plate 2, Figures 16-18 and Plate 3, Figures 31-33)

Species similar in appearance to the specimen considered here as *Angaria cf. guntheri*. It differs from the new species by having a white infrasutural cordlet, other cordlets creamy and straight or irregular; bright rose-red inner umbilical tract and off-white to creamy upper surface with a rosy subsutural band. Early whorls Eugenia red changing to creamy-white lower whorls with a wide zone of pomegranate purple interstitial markings, set between off-white growth threads and lamellae on the last



whorl. Sculpture coarser, especially on the sutural ramp; and scales more acute, larger. Shoulder and median keels moderately strong, except spines are somewhat flattened, longer and honey yellow with white markings, slightly darker than finer spirals. Sutural ramp almost flat with creamy radial folds that are angular in profile, curved or slanted forward and unevenly positioned, wide and thickened toward suture and obsolescent toward lip; furrows shallow and paler than ridges. Basal keel only weakly developed with small spines, base rounded and aperture wider, outline sub-pentagonal.

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<https://doi.org/10.54173/F534261>





**Plate 1.** Comparison and contrast of *Angaria* species living closest to *Angaria stevenliei* n. sp. in Indonesia. **First row, Figures 1-3** = *A. stevenliei* n. sp. Holotype MNHN-IM-2000-35827; **Second row, Figure 4** = *A. delphinus* LSL.527, specimen or probable syntype; **Figure 5** = *A. delphinus* Zamboanga, Philippines (JP); and **Figure 6** = *A. javanica* Pangandaran Bay, SW Java, Indonesia (JP); **Third row, Figures 7-9** = *A. cf. guntheri* Moluccas (Maluku), Indonesia ZMA.MOLL.310442; [Image credits: 1-3 and 5-6 JP; 4 modified from D. & K. Monsecour, 2011 plate 3, figure 21; 7-9 modified from Dekker, 2020 plate 6, figure 3].





**Plate 2.** Non-Indonesian relatives of *Angaria stevenliei* n. sp. **First row, Figures 10-12** = *A. fratummonsecourorum* Paratype SMNS ZI0076692; **Second row, Figures 13-15** = *A. guntheri* Holotype MNHN-IM-2000-34018; **Third row, Figures 16-18** = *A. scalospinosa* Holotype MNHN-IM-2000-30064; [Image credits: **10-12** copyright SMNS, 2018, photo: Mike Severns; **13-15** M. Caballer - 2019 Project: RECOLNAT (ANR-11-INBS-0004); and **16-18** M. Caballer - 2016 Project: RECOLNAT (ANR-11-INBS-0004)].



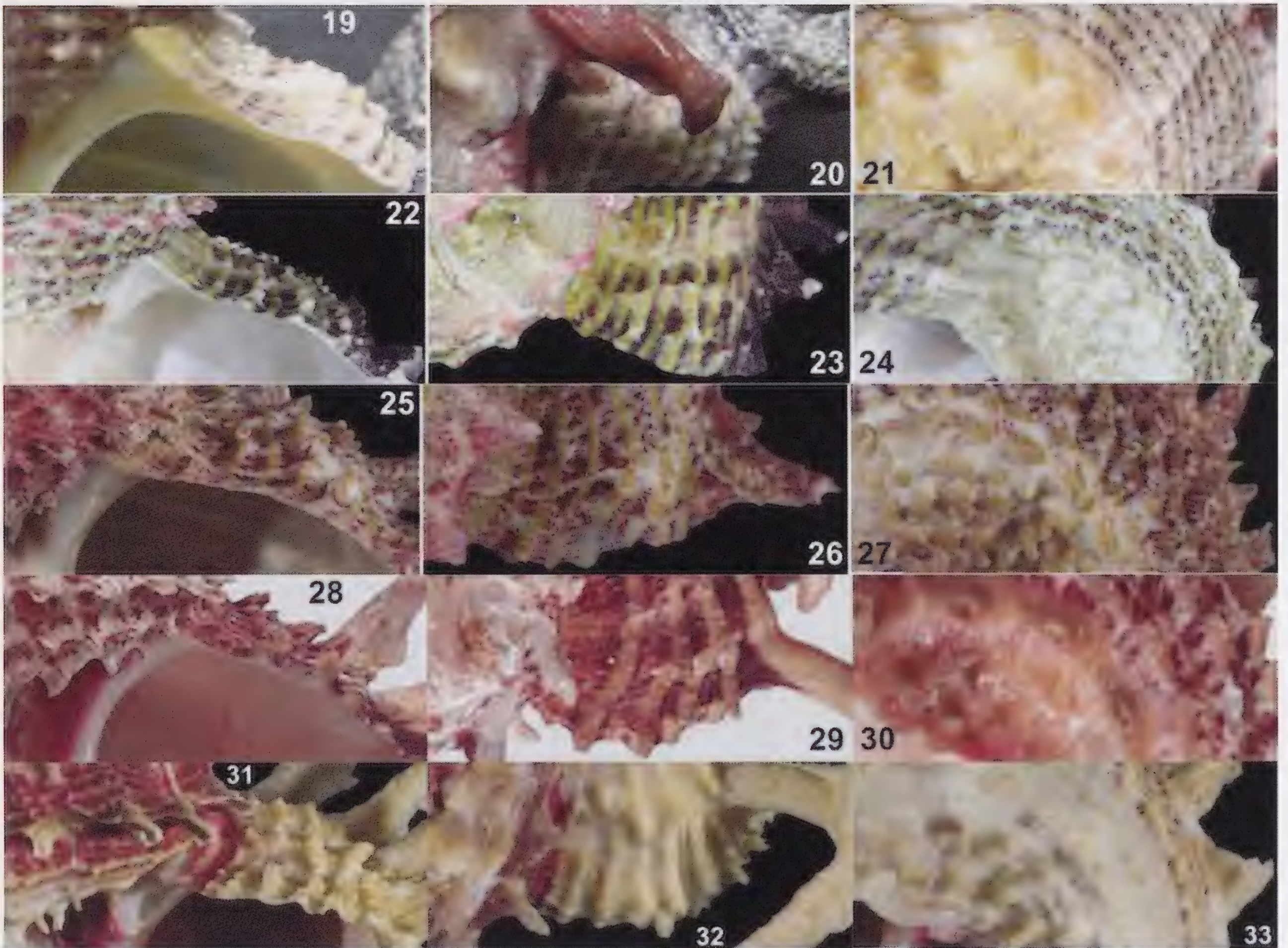


**Plate 3.** Comparison and contrast of sculpture and interstitial markings or coloration on *Angaria stevenliei* n. sp. with those on closest relatives shown in plate 1. **First row, Figures 19-21** = *A. stevenliei* n. sp. Holotype MNHN-IM-2000-35827; **Second row, Figures 22-24** = *A. fratummonsecourorum* Paratype SMNS ZI0076692; **Third row, Figures 25-27** = *A. guntheri* Holotype MNHN-IM-2000-34018; **Fourth row, Figures 28-30** = *A. cf. guntheri* Maluku ZMA.MOLL.310442; **Fifth row, Figures 31-33** = *A. scalospinosa* Holotype MNHN-IM-2000-30064; [Image credits: JP, modified from figures in first plate]



## Studies in *Canarium urceus* (Linné, 1758) Part 4: *Canarium (Canarium) orrae* (Abbott, 1960) (Gastropoda: Neostromboidae: Strombidae) and a new species from the Northern Territory, Australia

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**ABSTRACT** This part of the *Canarium (Canarium) urceus* (Linné, 1758) after Abbott (1960) revision examines the Australian species of that complex. Currently, there is one recognised species, *Canarium (Canarium) orrae* (Abbott, 1960), which is divided herein into two species, with the description of *Canarium (Canarium) darwinense* n. sp. from the Van Diemen Gulf and Darwin surrounds. The *C. (C.) darwinense* is distinguished from *C. (C.) orrae* in morphological form. The southern range of *C. (C.) orrae* is extended to Monkey Mia, Shark Bay. Examples of *C. (C.) orrae* were also noted from the North Coast of Sumbawa, Indonesia, and Port Moresby, Papua New Guinea. While there is a geographic break in the distribution of *C. (C.) orrae* creating two populations, Western Australian and Gulf of Carpentaria, populations from these two ranges could not be distinguished using morphology. Future research will likely show genetic differences as a consequence of drift caused by isolation, thus leading to the potential recognition of two cryptic subspecies.

**KEYWORDS** *Canarium*, *C. orrae*, *C. darwinense*, Northern Territory, *Strombus*, Western Australia

### INTRODUCTION

Recent studies of the *Canarium (Canarium) urceus* (Linné, 1758) complex (Abbott 1960) have led to a significant recognition of species that have either been buried within the synonymy of that species (Dodge 1946, 1956; Abbott 1960; Maxwell *et al.* 2020a), or aggregated to form an oversimplified taxonomy (Maxwell *et al.* 2020b; Dekkers & Maxwell 2020a, b). Abbott (1960, p. 63) described *Strombus (C.) urceus* with a focus of not distinguishing those taxa, which “in addition to size, sculptural and color variations that appear within a single colony, there are other geographical clines and groups of morphological variations limited to certain rather discrete geographical areas”, a mindset

that does not give taxonomic justice to the recognition of potential diversity within the *urceus* complex.

The distribution of *Canarium* examined in this study falls within the Damperian Province, which ranges from Shark Bay in Western Australia north to the Gulf of Carpentaria (Wilson 2013; Petuch & Berschauer 2020). The Damperian Province is further divided into several distinctive mesoscale biogeographical regions (Thackway & Cresswell 1998; Petuch & Berschauer 2020), each of which reflect localised species distributions; one example of *Canarium* from Darwin shows distinctive regional consistency in form that distinguishes this population from other areas in the province and justifies species recognition.



ABBREVIATIONS

- AM Australian Museum, Sydney, New South Wales, Australia.
- AMD Aart M. Dekkers Collection, Purmerend, The Netherlands.
- CC Barbra Collins Collection, Cairns, Queensland, Australia.
- LC Lesley Colliver Collection, Geraldton, Western Australia, Australia.
- NMV Museums Victoria, Melbourne, Victoria, Australia.
- QM Queensland Museum, Brisbane, Queensland, Australia.
- SMC Stephen Maxwell Collection, Cairns, Queensland, Australia.
- VC Valda Cantamessa Collection, Proserpine, Queensland, Australia.
- WAM Western Australian Museum, Perth, Western Australia, Australia.
- YC Trevor and Margarette Young Collection, Townsville, Queensland, Australia.

METHODS

Three hundred specimens were examined, and Australian specimens were divided into three distinctive bioregions, with two external Australian examples: first, North Western Biotone, the Van Diemen Gulf and area surrounding Darwin, containing the new species (Figure 1, yellow enclosed area, n = 109); second, the The Exmouthian Subprovince contains most of the western Damperian Province and contains the western population of *C. (C.) orrae* (Figure 1, green enclosed area, n = 167); third, the Groote biogeographical region, containing the eastern population of *C. (C.) orrae* (Figure 1, red enclosed area n = 22); and two specimens were observed outside of Australia, one each from Indonesia and Papua New Guinea (see Figure 1). The Arnhem-Wessel region (Figure 1, pink enclosed area) has not been included in this study as material

was not made available to the authors by the Museum and Art Gallery of the Northern Territory when requested.

Locality records were divided into three categories: first, material at hand; second, literary records; and third institutional records (QM, NMV, WAM) taken from the Atlas of Living Australia (ALA 2021). However, there are two limitations on the use of digital and literary historical records without accompanying illustrations: first, the correctness of the species identification underpinning each record has not been confirmed; and second, there is a reliance on the accuracy of the data provided with each specimen. For the purposes of this study, locality records were listed under the species that share a similar range. This assumes that each species has a defined geographical boundary. Locality data were divided by Country or Australian state/territory and listed under the distributional records for each species and then mapped (Figure 1).

We provide a redescription of the morphological characteristics of comparative species to provide clarity and to assist the discernment of the novel taxon. The decision to use the rank of species or subspecies is based on Maxwell and Dekkers (2019) and Maxwell *et al.* (2021). Under this system, the subspecies rank should be restricted to those taxa where there are no other forms of discrimination other than phenetic differences in genetic sequences.

SYSTEMATIC PART

|             |                                                        |
|-------------|--------------------------------------------------------|
| Superfamily | Stromboidea Rafinesque, 1815                           |
| Epifamily   | Neostromboidae Maxwell, Dekkers, Rymer & Congdon, 2019 |
| Family      | Strombidae Rafinesque, 1815                            |
| Subfamily   | Neostrombinae Maxwell & Rymer, 2021                    |



Tribe Neostrombini Liverani, Dekkers & Maxwell, 2021  
 Genus *Canarium* Schumacher, 1817  
 Subgenus *Canarium* Schumacher, 1817

*Canarium (Canarium) orrae* (Abbott, 1960)  
 (Figures 2-3 and 5E-O)

### Synonymy.

1960 *Strombus (Canarium) urceus orrae*  
 Abbott, p. 66, pl. 41, fig. 5. Wilson  
 and Gillett 1971, p. 40, p. 18, figs.  
 2a-b. Wilson and Gillett 1974, p. 40,  
 pl. 18, figs. 2a-b. Wilson and Gillett  
 1979, p. 73, pl. 14, figs. 2a-b.  
 Coleman 1975, p. 90. Walls 1980, p.  
 109, fig. 110. Kreipl *et al.* 1999, pp.  
 12 and 40, pl. 77.  
 = *Strombus orrae* Abbott – Dekkers  
 and Maxwell 2020b, fig. 5.  
 = *Strombus (Canarium) orrae*  
 Abbott – Liverani *et al.* 2021, p. 30,  
 fig. 2.

*Strombus urceus* Wilson 1993, p. 156, pl.  
 21, figs. 5 a-c.

**Original Description.** “This new subspecies is characterised and distinguished from the southwest Pacific typical *urceus* by its heavier, more quadrate, less coloured shell, its stronger and fewer nodules and its shorter siphonal canal. Its penultimate whorl bears 7-11 knobs (instead of as many as 10 to 16 as in typical *urceus*). The top of the outer lip is square and thickened; the columella is always white and the inner aperture with sparse brown lirae. Body whorl with 7 to 9 nodules at the shoulder, the first one of two at the shoulder being large, swollen and prominent. The young show a narrow, broken spiral band of brownish black on the body whorl. Nuclear whorls 2.5, translucent yellowish and glossy” (Abbott 1960, p. 66).

**Type Material.** Holotype – ANSP no. 247756. Paratypes – ANSP no. 232673; 233409; 240131; 240137.

**Type Locality.** Augustus Island, Western Australia (Abbott 1960).

**Supplementary Diagnosis.** The shell is elongated and fusiform. The teleoconch is high and strongly plicated with large regular shoulder knobs. The ventral body whorl is axially plicated and these from regular knobs on the angulate shoulder, and continue to the mid-whorl; these plications may be strong to weak. The colour of the ventral body whorl is variable and not typically restricted to the lower third. The top of the outer lip is square and thickened; the stromboid sinus is well developed and the flange is not strongly developed. The columella is always white and the inner aperture has sparse brown lirae. The outer lip typically joins below the shoulder.

**Locality Records. Literary Records:** *Western Australia* – Augustus Island (Abbott 1960); Broome (Abbott 1960); Cape Leveque (Abbott 1960); Dampier Archipelago (Slack-Smith and Bryce 2004); Gantheaume Point, Broome (Abbott 1960); La Grange Bay (Abbott 1960). *Northern Territory* – Groot Eylandt (Abbott 1960); Bickerton Island (Abbott 1960). **Institutional Records:** *Western Australia* – 22 km South of Exmouth (NMV F152000); 80 mile Beach south end, Cape Keraudren (F233792); Adele Island (WAM S46615, S46635); Augustus Island, Bonaparte Archipelago (NMV F28768); Back Beach, Dampier (NMV F233795; QM MO83450); Barred Creek (NMV F28786); Black Ledge area, Broome (QM MO83449); Brecknock Island, Bonaparte Archipelago (WAM S46618, S46619); Broome (NMV F28949, F233790; WAM S46588; QM DM11576073); Bundgei Reef (NMV F151685); Cambridge Gulf



(F28875); Camden Sound (WAM S46599); Cape Leveque (AM 77745; QM MO67999; NMV F233800, F28763); Cassini Island, Bonaparte Archipelago (WAM S46591, S46592); Cleaverville, Dampier (NMV F152005, F233717); Cockatoo Island, Buccaneer Archipelago (NMV F19849; WAM S46598, S46633); Corneille Island, Bonaparte Archipelago (WAM S46594); Coronation Island, Bonaparte Archipelago (WAM S46617); East Monalivet Island (WAM S46602); Finucane Island (NMV F151687); Jones Island (WAM S468281; QM MO56772); Karratha (NMV F233716); Lesueur Island (WAM S46601); Long Island, Buccaneer Archipelago (WAM S46614); Montgomery Reef (WAM S46646); One Arm Point (NMV F233719); Pender Bay (NMV F28779); Scorpion Island, Sir Graham Moore Islands (S46596); Sunday Island, Buccaneer Archipelago (WAM S46631, S46590); Troughton Island (WAM S46616); Turtle Bay (NMV F233798); Yampi Sound, Buccaneer Archipelago (NVM F28784). *Northern Territory* – Groote Eylandt Island (QM MO38297; MO38332).

**Material Examined:** *Western Australia* – Augereau Island (VC x 2); Back Beach, Dampier (VC x 5); Broome (AMD x 2, SMC x 46); Bundeyi Beach (SMC x 3); Cape Leveque (AMD x 3); Cassini Island (SMC x 1, VC x 4); Dampier (AMD x 1); Dixon Island, Wickham (VC x 4); East Moore Island, Balla Balla (VC x 5); Exmouth (SMC x 1, VC x 2, YC x 1); Forty Mile Beach (SMC x 8, VC x 6); Gnoorea (AMD x 1); Intercourse Island, Dampier (SMC x 12, YC x 1); King Sound (SMC x 2, YC x 1); Middle Mangrove Island, Onslow (AMD x 2); Monkey Mia, Shark Bay (BC x 4); Onslow (SMC x 6, VC x 8); Port Smith, Broome (VC x 4); Pretty Pool, Port Headland (SMC x 7, VC x 9); Roebuck Bay (VC x 10); Walcott Inlet, Kimberley (SMC x 4, VC x 2); *Northern Territory* – Bing Bong (AMD x 8); Drimmie Head, Gove (BC x 4); Hardy Island (AMD x 1);

Wallaby Beach, Gove (BC x 8); and Wessel Island (SMC x 1). *Indonesia* – North Coast of Sumbawa (LC x 1). *Papua New Guinea* – Port Moresby (AMD x 1).

**Comparison and Remarks.** It is expected that the two geographically isolated populations of *C. (C.) orrae* will be taxonomically separated by genetic evidence, a consequence of drift effects from the separation of the populations, and these will be divided at the subspecies level (Maxwell & Dekkers 2019; Maxwell *et al.* 2021). *Canarium (C.) orrae* stands out from other species in the *C. (C.) urceus* complex by the relatively stable morphology and large size, the high teleoconch that is strongly knobbed, the strong axial ribbing on the ventral side (although that is not always the case, and smooth ventral sides do occur), and the simple whitish colour.

*Canarium (Canarium) darwinense* Maxwell & Dekkers, new species  
(Figures 4 and 5A-D)

### Synonymy.

- 1960 *Strombus (Canarium) urceus orrae* Abbott, pl. 20, fig. 28.
- 1980 *Strombus (Canarium) urceus incisus* Wood – Walls, p. 107.
- 1987 *Strombus (Canarium) urceus* Linné – Short and Potter, p. 34, pl. 16, fig. 10.

**Description.** The shell is strongly bitriangulate with the body whorl being much wider than the final whorl of the spire. The teleoconch is low and the plications are fine, triangulate and regular, not forming distinct nodules at the shoulder. The posterior of the outer lip is square and thickened, causing a strong contraction of the aperture. The outer lip protrudes forming a strong callused knob, the mid-outer lip is thickened and the stromboid sinus is narrow,



with a large flange give the impression of a 'U' shape between the posterior callus and the sinus; the columella is always white and the inner aperture has sparse brown lirae. The ventral body whorl is not axially plicated, and the rounded angulate shoulder has knobs that are blunt, becoming stronger dorsally. Ventral body whorl colouration is typically restricted to the lower third of the body whorl, this colour being a brown stain. The outer lip typically joins at or just below the shoulder.

**Type Material.** Holotype – Lee Point, Darwin, 42 mm, 2020 (QM MO 85658); Paratype 1 – Lee Point, Darwin, 28 mm, 2020 (SMC 20a.001a); Paratype 2 – Lee Point, Darwin, 32 mm, 2020 (SMC 20a.001b); Paratype 3 – Lee Point, Darwin, 42 mm, 2020 (SMC 20a.001c); Paratype 4 – Lee Point, Darwin, 42 mm, 2020 (SMC 20a.001d); Paratype 5 – Lee Point, 40 mm, 2000 (SMC 20a.002a); Paratype 6 – Lee Point, 38 mm, 2000 (SMC 20a.002b); Paratype 7 – Casuarina, 43 mm, 1970 (AMD STR0782); Paratype 8 – Casuarina Beach, 40 mm, 1970 (AMD STR0782).

**Type Locality.** We designate Lee Point, Darwin.

**Etymology.** Named after the Darwin region where the species is well established.

**Locality Records. Literary Records:** *Northern Territory* – Shell Island, Darwin (Abbott 1960); East Point, Darwin (Abbott 1960); Port Darwin, Darwin (Abbott 1960); Quail Island, 35 miles west of Darwin, (Abbott 1960); and Nightcliff Point, Darwin (Abbott 1960). **Institutional Records:** *Northern Territory* – Gunn Point Beach, Darwin (NMV F151986); Tree Point, Darwin (QM MO46855); Shoal Bay, Darwin (NMV F233793); Port Darwin, Darwin (NMV F28765); Vesteys Beach, Darwin (QM MO28495). **Material Examined:** *Northern Territory* – Darwin (AMD x 1; VC x 5; YC x 1);

Casuarina, Darwin (AMD x 2); Lee Point, Darwin (AMD x 4; SMC x 81; VC x 1); Dripstone Cliffs, Darwin (SMC x 7); One Arm Point (VC x 2); Timor Sea (VC x 3); Vesteys Beach, Darwin (SMC x 2).

**Comparison and Remarks.** *Canarium* (*C.*) *darwinense* is a geographically isolated form that forms a number of colonies, with current evidence having the species restricted to the Darwin region. The strongly calloused outer lip, strong stromboid flange and narrow stromboid sinus, coupled with the bitriangulate shell distinguish *C. (C.) darwinense* from *C. (C.) orrae*. The new species *C. (C.) darwinense* should first be compared with *C. (C.) orrae* with which it has been confused for so many years until this part of the *C. (C.) urceus* complex revision. Compared to *C. (C.) orrae*, the new species has a shorter spire, more cone-like form of the shell with a broader shoulder, a wrinkled upper part of the aperture and a large extension beside the very shallow strombid notch ("strombid lobe" in Dekkers, 2021). In addition, it bears a brown colour stain on the anterior channel, which is lacking in *C. (C.) orrae*. The new species shares the more cone-like form of *C. (C.) manintveldi* Dekkers & Maxwell, 2020 from Vanuatu and the New Hebrides. However, that species is mostly much smaller (around 25 to 30 mm) and smoother on the body whorl, with an even shorter spire, the posterior ending of the aperture is raised high towards the apex, and lacks the elongation of the strombid lobe.

## DISCUSSION

This paper erects a geographically consistent species from the North Western Biotone containing the Van Diemen Gulf and area surrounding Darwin. The localised range of *C. (C.) darwinense* is characterised by diverse tropical environments including large estuarine drainage systems, mangrove flats, localised



intermittent fringing reefs and rocky headlands (Thackway & Cresswell 1998). The Exmouthian Subprovince contains most of the western Damperian Province and the western range of *C. (C.) orrae*, and may contain *C. (C.) darwinense* in the Kimberly Region. The Northern Region contains the Groote biogeographical region, which contains the most easterly records of *C. (C.) orrae*. This region has well developed localised fringing coral reefs, and extensive seagrass beds separated by narrow fringing mangrove stands (Thackway & Cresswell 1998). There is no record of *C. (C.) darwinense* found in this region. The western Northern Biozone, the Arnhem-Wessel region, is relatively unexplored in terms of its biodiversity; reefs tend to the eastern border regions with the Groote Biogeographical region, and there are sporadic records of *Canarium* in that region (ALA 2021), but the form of these is unknown at present to the authors. It is likely that the Arnhem-Wessel region will contain both *C. (C.) orrae* and *C. (C.) darwinense* due to veliger dispersal.

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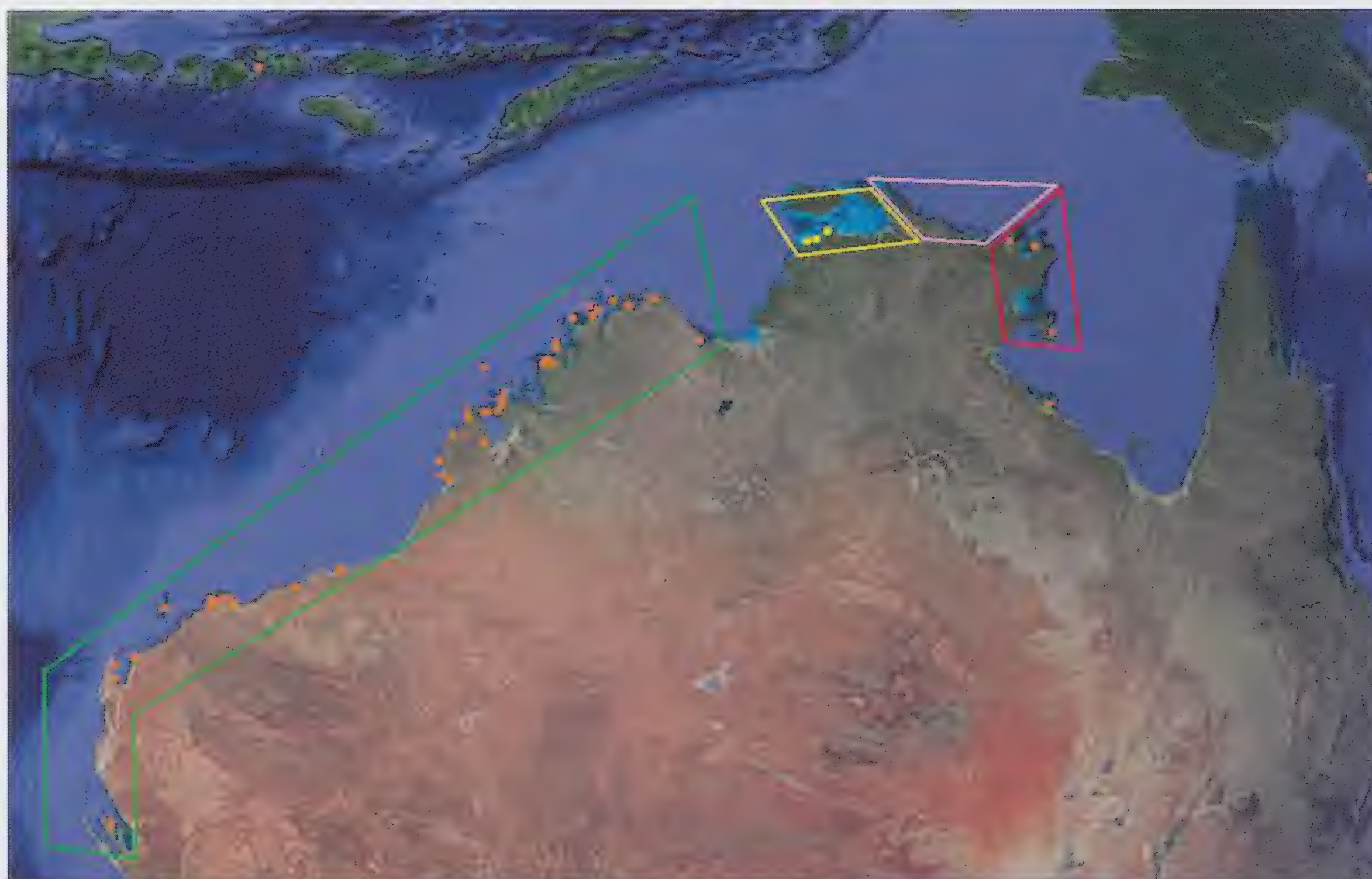


**Figure 1.** Distribution of *Canarium (Canarium) orrae* (orange dots) and *Canarium (Canarium) darwinense* (yellow dots): The Exmouthian Subprovince (Green bordered region – *C. (C.) orrae*); The Arnhem-Wessel Region (Pink bordered region – material from this region was not seen); The Van Diemen Gulf and Darwin (Yellow bordered region – *C. (C.) darwinense*); and The Groote Biogeographical Region (Red bordered region – *C. (C.) orrae*). Outliers from the Damperian Province shown include: Bing Bong, Northern Territory; Port Moresby, PNG; and the North Coast of Sumbawa, Indonesia.





**Figure 2.** *Canarium (Canarium) orrae* (Abbott 1960) from The Exmouthian Subprovince: A) King Sound, 36 mm, 1976 (SMC 20.001a); B) Bundeyi Beach, 52 mm, 1983 (SMC 20.007b); C) Forty Mile Beach, 31 mm, 2017 (SMC 20.010a); D) Pretty Pool, Port Headland, 44 mm, 2017 (SMC 20.013a); E) Cassini Island, 24.3 mm, 2013 (SMC 20.002); F) Exmouth, 45 mm, 1989 (SMC 20.009); G) Dampier, 28 mm, 2011 (SMC 20.008a); H) Bundeyi Beach, 51 mm, 1983 (SMC 20.007a); I) Dampier, 26 mm, 2011 (SMC 20.008a).





**Figure 3.** *Canarium (Canarium) orrae* (Abbott 1960) from The Carpentarian Subprovince – Groote Biogeographical Region: A) Drimmie Head, Gove, 37 mm (BC); B) Drimmie Head, Gove, 40 mm (BC); C) Drimmie Head, Gove, 34 mm (BC); D) Wallaby Beach, Gove, 45 mm (BC); E) Wallaby Beach, Gove, 48 mm (BC); F) Wallaby Beach, Gove, 50 mm (BC); G) Wallaby Beach, Gove, 45 mm (BC); H) Wessel Island, Northern Territory, 1996, 37 mm (SMC 20.003).





**Figure 4.** *Canarium* (*Canarium*) *darwinense* n. sp. from Van Diemen Gulf and Darwin: A) Holotype – Lee Point, Darwin, 42 mm, 2020 (QM MO 85658); B) Paratype 1 – Lee Point, Darwin, 28 mm, 2020 (SMC 20a.001a); C) Paratype 2 – Lee Point, Darwin, 32 mm, 2020 (SMC 20a.001b); D) Paratype 3 – Lee Point, Darwin, 42 mm, 2020 (SMC 20a.001c); and E) Paratype 4 – Lee Point, Darwin, 42 mm, 2020 (SMC 20a.001d).





**Figure 5.** *Canarium* (*Canarium*) *darwinense* n. sp.: A) Paratype 5 – Lee Point, 40 mm, 2000 (SMC 20a.002a); B) Paratype 6 – Lee Point, 38 mm, 2000 (SMC 20a.002b); C) Paratype 7 – Casuarina, 43 mm, 1970 (AMD STR0782); D) Paratype 8 – Casuarina Beach, 40 mm, 1970 (AMD STR0782). *Canarium* (*Canarium*) *orrae* (Abbott 1960): E) Walcott Inlet, 38 mm, 2013 (SMC 20.011a); F) Walcott Inlet, 37 mm, 2013 (SMC 20.011b); G) Walcott Inlet, 40 mm, 2013 (SMC 20.011c); H) Broome, 47 mm, 2013 (SMC 20.005a); I) Broome, 42 mm, 2013 (SMC 20.005b); J) Broome, 47 mm, 2013 (SMC 20.005c); K) Broome, 45 mm, 2013 (SMC 20.005d); L) Onslow, 41 mm, 2013 (SMC 20.006a); M) Onslow, 41 mm, 2013 (SMC 20.006b); N) Onslow, 40 mm, 2013 (SMC 20.006c); O) Onslow, 38 mm, 2013 (SMC 20.006d).



## Studies in *Canarium urceus* (Linné, 1758) Part 5: a New Species from the Northern Pacific Ocean (Gastropoda: Neostromboidae: Strombidae)

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**ABSTRACT** This part of the *Canarium* (*Canarium*) *urceus* (Linné, 1758) revision after Abbott (1960) revision examines the northwest Pacific specimens, which are currently synonymised under *Canarium* (*Canarium*) *urceus* (Linné, 1758). *Canarium* (*Canarium*) *nipponium* n. sp. is known from the Ryukyuan Subprovince, Mariana Islands and Palau. The new species differs from others in lacking the fine sculpture on the early whorls and triangulate from. Given the propensity for species of Strombidae to disperse widely, to show a high degree of variability across their ranges, and to hybridise, it is expected that traits of this new species will be present in populations of neighbouring species, particularly within the *Canarium* (*Canarium*) complex.

**KEYWORDS** *Canarium*, *C. urceus*, *C. nipponium*, Japan, Mariana Islands, Palau, *Strombus*, Ryukyuan Subprovince

### INTRODUCTION

The *Canarium* (*Canarium*) *urceus* (Linné, 1758) complex (Abbott 1960) has recently been significantly revised, with the identification of many new species within bioregions of the Indo-Australian Archipelago realm (Maxwell *et al.* 2020a; 2020b; Dekkers and Maxwell 2020). There is a sound basis for the recognition of species based on biogeographic boundaries based on the phylogenetic history of a diverse set of marine organisms within the Indo-Australian Archipelago realm (Santini and Winterbottom 2002; Spalding *et al.* 2007; Carpenter *et al.* 2011; Borsa *et al.* 2016; Kulbicki *et al.* 2013; Veron *et al.* 2015; Yang *et al.* 2016; Wainwright *et al.* 2018). The distribution of *Canarium* examined in this study falls within the Ryukyuan Subprovince and the Mariana Chain of Islands, which is considered outside and to the north of the Indo-Australian

Archipelago realm (Petuch and Berschauer 2020; Figure 1).

### ABBREVIATIONS

AMD Aart M. Dekkers Collection, Purmerend, The Netherlands.

SMC Stephen Maxwell Collection, Cairns, Queensland, Australia.

### METHODS

The rarely observed species described in this paper is based on two specimens, one from the Hahajima Retto, Ogasawara Islands, and one collected from Ryukyu (Figure 1). The Ryukyu specimen was obtained from Thora Whitehead, Brisbane, Australia, and was collected prior to the 1970s. The Hahajima Retto, Ogasawara Islands specimen was obtained from a dealer, and was collected in the 1950s. The species is also illustrated in the molluscan literature of



Japan (Hirase 1936, 1954; Kira 1959). While the number of physical specimens at our disposal is limited, the morphological similarity of the material from two sources, the illustrations of it in literature (under the "*urceus*" name), and the morphological distinctiveness from other *Canarium* (*Canarium*) justifies their recognition.

The decision to use the rank of species or subspecies is based on Maxwell and Dekkers (2019a, b) and Maxwell *et al.* (2021). Under this system, the subspecies rank should be restricted to those taxa where there are no other forms of discrimination other than phenetic differences in genetic sequences.

## SYSTEMATIC PART

|             |                                                                                                                                                 |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Superfamily | Stromboidea Rafinesque, 1815                                                                                                                    |
| Epifamily   | Neostromboidae Maxwell, Dekkers, Rymer & Congdon, 2019                                                                                          |
| Family      | Strombidae Rafinesque, 1815                                                                                                                     |
| Subfamily   | Neostrombinae Maxwell & Rymer, 2021                                                                                                             |
| Tribe       | Neostrombini Liverani, Dekkers & Maxwell, 2021                                                                                                  |
| Genus       | <i>Canarium</i> Schumacher, 1817                                                                                                                |
| Subgenus    | <i>Canarium</i> Schumacher, 1817<br>(Type species – <i>Canarium ustulatum</i> Schumacher, 1817 = <i>Canarium (urceus) urceus</i> (Linné, 1758)) |

*Canarium (Canarium) nipponium* Maxwell & Dekkers, new species  
(Figure 1)

## Synonymy.

1936 *Strombus ustulatus* Schumacher – Hirase, pl. 86, fig. 11, and Hirase 1954, pl. 86, fig. 11.

1959 *Strombus ustulatum* Linné – Kira, p. 35, pl. 15, fig. 4.

**Diagnosis.** Solid shells with triangular body whorl. The shoulders of the whorls are angulated and the early whorls lack fine sculpture. The posterior aperture is restricted. Body whorl covered with many very narrow spiral lines.

**Description.** The shell is heavy and solid. The shape is ovate to fusiform with an extended anterior sinus (broken in holotype) that is not dorsally exposed. The stromboid sinus is acute and axially angled in the direction of shell growth, and has a thin protruding flange that is quadrate and typically dark stained with black to brown both externally and internally. The ventral shoulder has reduced blunt knobs that continue to the dorsum with three well defined blunt shoulder knobs, and one greatly reduced knob prior to the formation of the outer lip. There are fine axial incised lines on the lower third of the body whorl both dorsally and ventrally. Early teleoconch whorls are rounded and smooth, with a distinctive subsutural ramp. Later whorls become more angulate at the shoulder, developing axially elongated shoulder knobs, with fine well-spaced spiral incised lines that do not extend to the body whorl. The spire often has a purplish tint. The aperture is lanceolate, being restricted at the posterior end, white, with very thin brownish lines entering the aperture on the inside of the lip. The columella is well formed and uniform along the aperture, having a yellowish hue. The other lip is thickened and somewhat quadrate posteriorly, joining at the shoulder of the body whorl, becoming thinner and sharp-edged anteriorly.

**Type Material.** Holotype – Ryukyu, Japan 37 mm MNHN-IM-2000-35893; Paratype 1 – Hahajima, Ogasawara Islands, Japan, (SMC 19g. 001).



**Type Locality.** We designate Ryukyu, Japan as the type locality.

**Etymology.** Named after the country of the type population, Japan.

**Locality Records. Literary Records:** Japan – Ryūkyū (Hirase 1936, 1954); Yaka Beach, Ishikawa (Abbott 1960). **Material Examined:** Japan – Hahajima, Ogasawara Islands, Japan (SMC x 1); Ryūkyū (SMC x 1). Palau – Palau Lagoon (AMD x 3).

**Comparison and Remarks.** *Canarium* (C.) *nipponium* n. sp. is similar in form to *C. (C.) darwinensis* Maxwell and Dekkers, 2021 and *C. (C.) manintveldi* (Dekkers and Maxwell, 2020) but lacks the fine sculpture on the early whorls of that species. *C. (C.) incisum* (Wood, 1828) differs in having a uniform orange aperture, a more triangulate shape. *C. (C.) urceus* (Linné, 1758) differs in form, having a more angulate shoulder on the body whorl, and the posterior aperture not restricted as it is in *C. (C.) nipponium* n. sp.. *Canarium* (C.) *anatellum* (Duclos, 1844) and *C. (C.) esculentum* (Maxwell, Rymer, Congdon & Dekkers, 2020b) lack the angulated whorls and shouldered aperture of the new species. Material from online sources ([www.stromboidea.de](http://www.stromboidea.de)) and literary references, indicate that *C. (C.) nipponium* n. sp. is presently restricted to the Ryukyuan Subprovince of Japan and the Mariana Islands south to Palau.

## DISCUSSION

There is growing evidence that the *C. (C.) urceus* (Linné, 1758) complex (Abbott 1960), despite variability in form and sharing of similar phenotypic traits (e.g. random presence of a black columella in some individuals), are also evolving in divergent directions, often within defined biogeographic provinces and zones. These recurrent morphological themes can be

explained in three ways: first, there is a lag between the time of genetic divergence and evidence of this split in the morphology of organisms (Baum 2008); second, within a population, there are enough carriers of a mutation that drift and selection maintain allelic frequency without leading to either extinction or fixation (Baum 2008); or third, there is enough genetic inflow from populations outside the particular bioregion that would enable recurrent introduction within a population of a particular morphological trait to sustain its ongoing recurrence (Delgado *et al.* 2006; Paris *et al.* 2006, 2008).

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**Figure 1.** Distribution of *Canarium (Canarium) nipponium* n. sp.: A) Holotype – Ryukyu, Japan 37 mm MNHN-IM-2000-35893; B) Paratype 1 – Hahajima Retto, Ogasawara Islands, Japan, (SMC 19g. 001) (Image modified from Google Earth, accessed August 2021).



## The Pacific Wing-Oyster, *Pteria sterna*, off San Diego, California

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**ABSTRACT** *Pteria sterna* is an eastern Pacific pearl oyster of commercial value from Perú to central Baja California, México. The continuous presence of this species in San Diego for a decade is unique as it is approximately 600 km north of the expected range for the species. A minimum of three generations are present in Mission Bay at any point in time and the preferred substrate for attachment are gorgonian corals. The species is also found off shore in cooler water. The continued presence of this oyster raises the question as to the status of this population; is it a permanent range extension or simply a transient population and what has changed that allowed its continued presence?

**KEY WORDS** Pearl Oyster, *Pteria sterna*, California, Substrate, Transient Population

### INTRODUCTION

Observations regarding the Pacific Wing-Oyster, *Pteria sterna* (Gould, 1851) are presented, based on populations in Mission Bay and off-shore Point Loma (San Diego, California). The expected distribution of this species is from Ancón, Lima, Perú, north to Morro Santo Domingo in the southern most portion of Baja California, and to the head of Golfo de California at Bahía la Choya, Sonora, México (Coan & Valentich-Scott, 2012; Valentich-Scott, *et al.* 2020). Those authors indicate the species has been infrequently found as far north as Goleta, Santa Barbara County, California and recognized the difference between a transient individual/population and a sustained range extension. Life history papers are reviewed in order to place the current observations and speculation reported here in context with studies from Latin America.

with similar efforts in both Perú and Ecuador (Ordinola *et al.* 2013; Lodeiros *et al.* 2018). As a result, research regarding this species has focused on aspects of mariculture, especially reproduction, diet, and growth related to the successful culture of pearls. *Pteria sterna* inhabits tropical, subtropical and temperate waters of the eastern Pacific (Serna-Gallo *et al.* 2014) and is listed as an endangered species in México, to protect depleted natural populations from harvest (Del Rio-Portilla *et al.* 1992; Saucedo & Monteforte, 1997).

Gametogenesis in subtropical and temperate waters occurs as the water begins to cool, with spawning typically between December and March (Hernandez-Olalde *et al.* 2007; Caceres-Puig *et al.* 2009; Saucedo & Monteforte 1997). At 21-22°C, the larvae settle out of the water column at approximately 38 days (McAnally-Salas & Valenzuela-Espinosa 1990). In some locations, various levels of reproductive activity occur throughout the year (Diaz & Buckle, 1996). Growth rate is related to food density and quality, water temperature, and age of the pearl oyster. As a result, growth rates can be quite variable between distant locations (Del

*Pteria sterna* is a pearl oyster in the family Pteriidae and is of economic importance, with México supporting notable mariculture activity related to pearl production (Saucedo & Monteforte, 1997; Serna-Gallo *et al.* 2014),



Rio-Portilla *et al.* 1992; Lodeiros *et al.* 2018, Wright-Lopez *et al.* 2009, Serna-Gallo 2014).

In southern California, *P. sterna* has been assumed to be a transient species associated with the occurrence of warm water El Niño events (Coan, *et al.* 2000; Valentich-Scott, *et al.* 2020). The population may increase during such events, but are they absent between El Niño events or simply less common? In 2010, a live specimen of *Pteria sterna* was observed by the author in Ventura Cove (Mission Bay) that measured 137 mm in height (Figure 1). Once regular observations began, the species was routinely present in the proper habitat, but never abundant. As of March 2021, their continued presence in Mission Bay for a decade has been observed.

*Pteria sterna* are most obvious when attached to various species of gorgonians. The red gorgonian *Lophogorgia chilensis* (Verrill, 1868) (Figure 2) and *Muricea californica* Aurivillius 1931 serves as the prominent substrate for the majority of *P. sterna* in the channel side of the rocky Mission Bay jetty, followed by *Muricea furciosa* Verrill 1869. The maximum depth in Mission Bay is approximately 10 m. Off-shore at 18-26 m, *Lophogorgia chilensis* hosts the majority of *P. sterna* observed at Three Fingers Reef. The thin shells of *P. sterna* are covered with fouling organisms, which makes them look like a clump of algal debris on the gorgonian (Figure 2). In the Golfo de California, between Santa Rosalia and Bahía Loreto, Wright-Lopez *et al.* (2009) reported the primary substrate for *P. sterna* as *Muricea californica*.

The gorgonian species are general indicators of good water flow, which brings particulate to the feeding polyps. The presence of *P. sterna* on gorgonians does not appear deleterious to the gorgonian unless the bivalve becomes large enough to bend the coral over. On the other

hand, with the pearl oyster nestled in the gorgonian, they appear to be out of reach of predatory sea stars and are well placed to also feed on particulates in the current.

In Mission Bay, there are multiple age classes present at the same time. During October 2019, one group averaged 32.2 mm in height (n=20, STD 3.7), and based on a spring settlement, they were perhaps 6-7 months old. Saucedo & Monteforthe (1997) indicated that shells between 40-45 mm were 11 months old, and reach 70-80 mm in 15-17 months. The second group averaged 82 mm (n=15, STD 7.6) and were estimated to be approximately 16-18 months old. Individuals from 100-135 mm were scarce and typically not attached to gorgonians, making it difficult to find them in suitable numbers to estimate subsequent age classes. Collecting the largest individuals to estimate longevity was not a priority, as it would have required sacrificing the more fecund individuals and such data already exists.

Wright-Lopez *et al.* 2009 studied the *P. sterna* population from Santa Rosalia to Bahía Loreto, Baja California Sur, and used a modified von Bertalanffy model to estimate growth. By the 3<sup>rd</sup> year, shell size was approximately 115 mm. The model indicated that some individuals may survive more than 5 years. The largest shells averaged 130.5 mm (range 124-136 mm) with the maximum projected size of 156 mm. Growth rates decrease sharply with age; the longevity of this species was estimated by Ordinola *et al.* (2013) to be 5-7 years. Variation in longevity estimates may reflect the suitability of the habitat and the number and types of predators.

In addition to Mission Bay, *P. sterna* occurs off-shore at Point Loma where they are observed at 18-26 m, at those depths summer water temperatures seldom exceed 18.9°C (66°F), and



winter temperatures may be 10 -14.4°C (50 - 58°F). In Mission Bay, summer water temperatures may range from 23.9 - 26.6 °C (75 - 80°F), with winter lows from 13.8 - 16.1°C (57 - 61°F). Although both depth and temperature differ, the habitat of Mission Bay and Point Loma, have three things in common. Both locations support numerous gorgonian species, have excellent water flow, and usually have little to no subtidal impact from waves. As of yet, *P. sterna* off-shore in water shallower than 18 m have not been observed. Although other gorgonians are present in shallow water, large winter swells cause strong bottom surge in shallower water that may dislodge developing *P. sterna* from the gorgonians.

During November 2020 to January 2021 there were extended periods with both high swells and surf from 2 - 4 m. In January 2021, people surfing inside the Mission Bay jetty on waves from 2 – 3 m in height were photographed. The waves were breaking over the normally protected habitat of the gorgonians and *Pteria* (Figure 3). In March 2021, *P. sterna* were still present on gorgonians near the transition from the channel to the bay, but in reduced numbers. No pearl oysters were observed on gorgonians in the channel exposed to the high surf. It is not known if *P. sterna* survived the heavy surf or not, as finding detached individuals on the rocky algae covered substrate is difficult.

As a broadcast spawner, the current population of *P. sterna* in Mission Bay may be less than required for successful fertilization. Either other areas off San Diego exist with greater density or this population may be in decline. It is also possible that the local population is supported by larvae drifting northward on the Inshore Counter Current from further south in Baja California. Based on the report by McAnally-Salas & Valenzuela-Espinosa (1990), larvae

settled at 38 days, therefore they may be transported great distances.

The Southern California eddy (SCE), dominates the Southern California Bight (SCB) and has interaction with other water masses, wind, and upwelling. Chenillat *et al.* (2018) published a detailed study in the SCB and found that smaller coastal eddies trap inshore water and as they detach from the shore, they tend to move northwest at an average rate of 2 km/day. The average coastal eddy within the SCB persists about three months but some last much longer. These eddies transport nutrient rich inshore water great distances off shore where they eventually dissipate (Chenillat *et al.* 2018). Larvae trapped in those eddies may not have the opportunity to return inshore to settle. The intensity and position of both the California Current from the north and the Coastal Counter Current from the south varies seasonally and annually, Bray *et al.* 1999. This variation adds complexity and variability to the transport of planktonic populations.

The continued presence of this species for a decade or perhaps longer, and apparent tolerance to temperate water suggests they may have had an historical presence that has been overlooked. The local population may be sustained by recruitment from larvae transported north via the Inshore Counter Current. How long must a species persist and reproduce in an area before it is considered to be a resident? When a species is at the extreme edge of its range, fluctuations in the population due to subtle or not so subtle changes in the marine habitat are not unexpected. The author suspects that *P. sterna* may still be a transient species in San Diego, but as sea water continues to warm perhaps other assessments over the next decades will answer the question, transient or not.



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**Figure. 1** = Mature *P. sterna*, umbo to ventral edge 137 mm, Mission Bay; **2** = Young winged pearl oyster, perhaps 6 months old on *Lophogorgia chilensis*, hinge to left, Point Loma; **3** = A perfect wave breaking over the gorgonian-*Pteria* habitat in the Mission Bay channel.

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## First Record of *Oleacina cyanozoaria* (Gundlach in Pfeiffer, 1857) Feeding on a *Eleutherodactylus* Frog in Pico San Juan, Cumanayagua, Cienfuegos Province, Cuba

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**ABSTRACT** Around twenty species of the landsnail subfamily Oleacininae inhabit Cuba. However, only five species were found in south-central region of the island. Despite the frequency of *Oleacina* in Cuba, these species have been poorly studied and little is known about their ecology, ethology and carnivorous feeding preferences. This field study is the first record showing *Oleacina cyanozoaria* to be an active predator on a small *Eleutherodactylus* frog. Small vertebrates have not been previously noted to be part of these voracious species' diet.

**KEYWORDS** *Oleacina*, *Eleutherodactylus*, Cuban carnivorous snails, predation

### INTRODUCTION

The carnivorous snails from subfamily Oleacininae (H. Adams y A. Adams, 1855) in Cuba encompass around twenty species from two different genera *Oleacina* (Röding, 1798) and *Rectoleacina* (Pilsbry, 1907) (Hernandez-Quinta, *et al.*, 2017: at p. 93). This is a subfamily which is found only in Cuba and Hispaniola. Of these mentioned genera, two species are seemingly distributed throughout the island; *Oleacina solidula* (Pfeiffer, 1840) and *Oleacina straminea* (Deshayes, 1819), and another three species can be found in the south central part of Cuba *Oleacina regularis* (Gundlach in Pfeiffer, 1857), *Oleacina subulata* (Pfeiffer, 1839), and *Oleacina cyanozoaria* (Gundlach in Pfeiffer, 1857). The shell shapes of *Oleacina* and *Rectoleacina* are elongated (bullet shaped) with a narrow aperture. None of the known Cuban species from Oleacinidae genera (*Oleacina*, *Rectoleacina*, *Varicella*, *Melaniella*, *Glandinella*) are well-studied related to their ecology and ethology.

Field observations of feeding habits in *Oleacina* are unavoidable because individuals are readily

observed hunting and scavenging in the leaf litter, soil, rocks and even on trees. We have observed these fast sharp toothed predators tracking their preys' mucus trails, and frequently "tasting" their prey with an initial bite before attack (Plate 1, sequence #1). *Oleacina* are also known to eat carrion, and sometimes engage in cannibalism; their most common prey are snails and slugs.

Among the Cuban *Oleacina* species, in our opinion *Oleacina cyanozoaria* stands alone for having the most voracious appetite and aggressive behavior. We observed this species feeding on prey during several land snail expeditions in different localities (*e.g.*, Pico San Juan (see Plate 2), San Juan de Letrán, Topes de Collantes and Botanical Garden of Cienfuegos). Particularly pugnacious slugs, which are also cannibalistic, such as agriolimacid *Deroceras laeve* (Müller, 1774) (Barker & Efford, 2004), do not seem to offer any defensive response when faced with an *O. cyanozoaria* attack (Plate 1, sequence #3). *Deroceras reticulatum* (Müller, 1774), another introduced slug in Cuba from the same genus, is considered an herbivore with



mere facultative carnivory (Barker & Efford, 2004).

## MATERIALS AND METHODS

Photographs were taken of *O. cyanozoaria* feeding on prey *in situ* during field studies.

## DISCUSSION

There are almost no accounts of *Oleacina* eating other carnivorous snails or small invertebrates in the literature. Photographs taken during the authors' field studies are the first record of a predation event where *O. cyanozoaria* was observed preying on a small *Eleutherodactylus* (Duméril and Bibron, 1838) frog, demonstrating this species' hunting behavior (Plate 1, sequence #4). It appears that, if the prey animal can fit into *O. cyanozoaria*'s extended muscular mouth and is palatable, there is a good chance that it will be consumed. In fact, the spheroidal buccal mass is markedly elongated and enlarged in *Oleacina* species (Barker & Efford, 2004). Small Cuban frogs do not secrete toxins like toads do, however they generally tend to be capable of jumping out of danger. Based upon our observations it is hypothesized that the *Oleacina* snail rubs a toxic secretion of its own making on the frog that has the effect of slowing down the frog.

Other carnivorous snails' genera worldwide consume earthworms (e.g., *Deroceras*, *Boettgerilla*, *Milax*, *Mesodon*, *Plutonia*, *Vitrina*, *Aegopinella*, *Daudebardia*, *Strangesta*, *Powelliphanta*, *Schizoglossa*, *Paryphanta*, *Victaphanta*, *Wainuia*, *Austrorhytida*, *Natalina*, *Rhytida*, *Streptaxis*, *Testacella*, *Hyrcaholestes* and *Meridolum*). Spheroidal buccal mass evolution has provided the ability to consume earthworms. It is assumed that during evolution "the elongation of the buccal mass lags considerably behind the adoption of an obligate

carnivorous feeding strategy" (Barker & Efford, 2004). The same authors opined that Oleacinidae family members exhibit transitional stages in buccal mass elongation and at least some of this variation corresponds to differences in carnivory. However, *Oleacina* specializes in snails and slugs, rather than earthworms, which was the prey previously reported prior to these field studies.

We presume that Cuban *Oleacina* can attack other carnivorous endemic snails' species from the genera *Haplotrema*, *Melaniella*, *Glandinella*, *Rectoleacina* or *Varicella*. Some might think is a matter of buccal mass size, a big *Oleacina* specimen cannibalizing or attacking only smaller individuals. However, we have direct personal observations in Sierra de los Órganos of fully-grown adult *O. straminea* specimens attacking each other aggressively. Even larger land snails and slugs were observed being harassed by *Oleacina* (e.g., *Eurycampta bonplandi* (Lamarck, 1822); *Veronicella cubense* (Pfeiffer, 1840); *Guladentia subtussulcata* (Wright in Pfeiffer, 1863); *Zachrysia guanensis* (Poey, 1857).)

No phoretic relationship is suggested among Cuban anurans and other snails; this is still a speculative theory in their ecology (Kolenda, *et al.*, 2017). However, some anuran species from Bufonidae (Gray, 1825) family are known predators of land snails and mostly slugs. In Cuba, some toads and frogs are noteworthy for including land molluscs in their diet [e.g., *Osteopilus septentrionalis* (Duméril and Bibron, 1841); *Peltophryne* spp. (Fitzinger, 1843)]. Several Cuban frogs are famous for their small size. Accordingly, juvenile frogs of these smaller species are likely a regular part of *Oleacina* species' diet of prey from the leaf litter.



## CONCLUSIONS

The Cuban *Oleacina* species are poorly studied. Despite being one of the most common lands snails thriving even on anthropic areas little is known about its feeding habits. Our finding of *Oleacina cyanozoaria* consuming a small *Eleutherodactylus* frog in south-central Cuba is only one example of this creatures' carnivorous behavior and palatable preferences.

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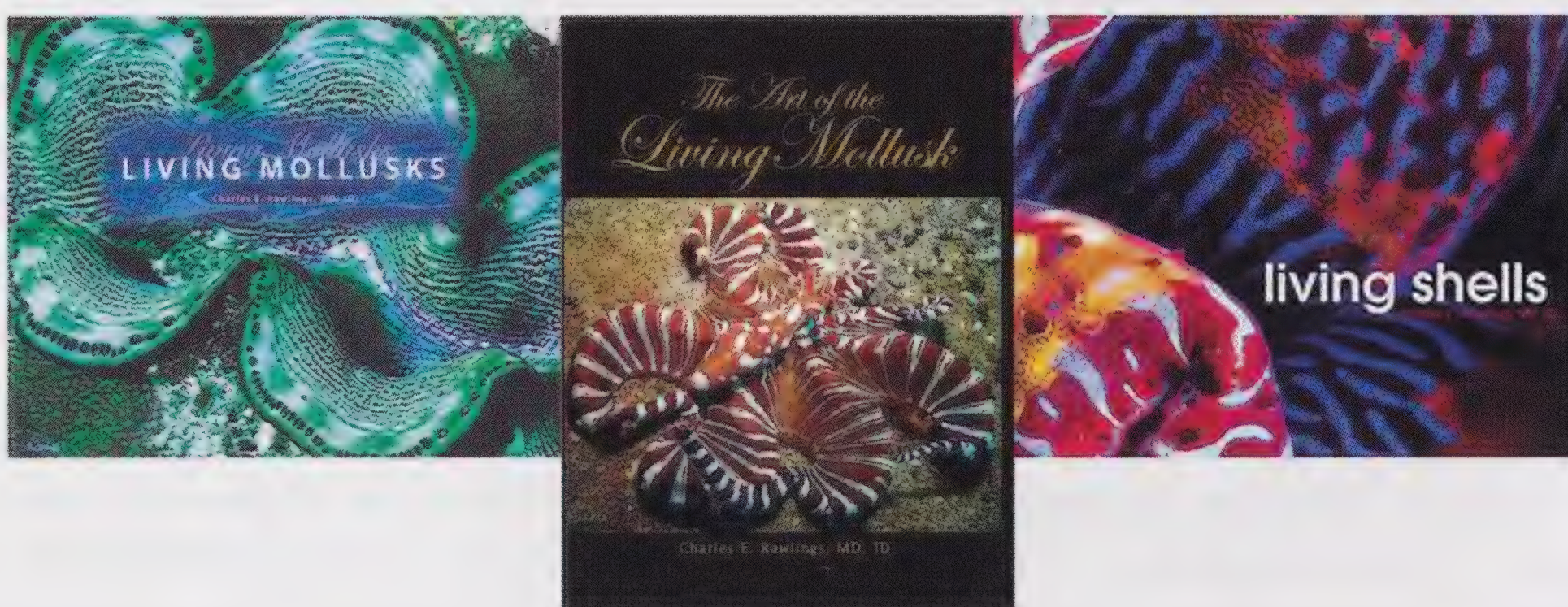
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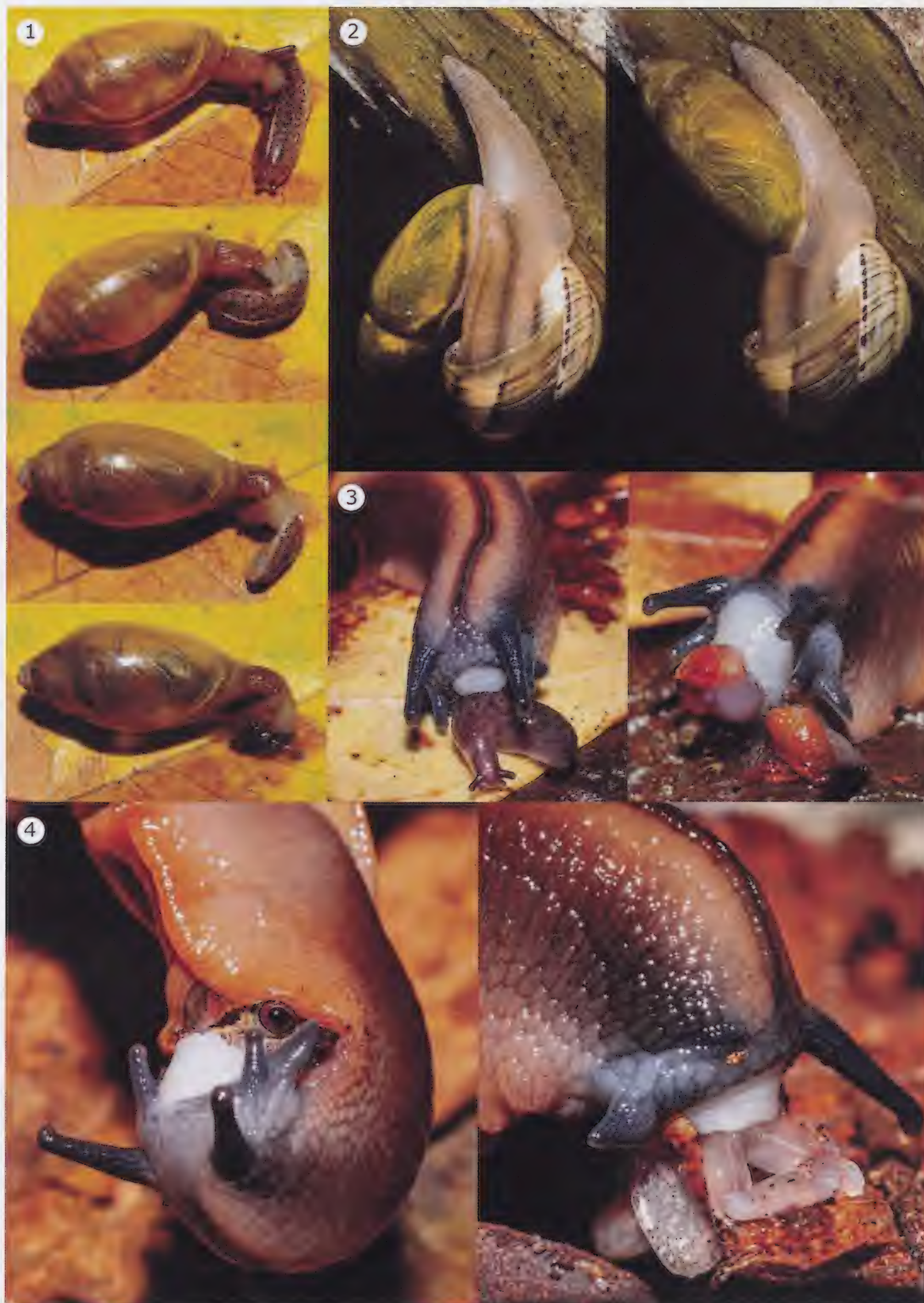


**Plate 1.** Sequence 1: A juvenile *Oleacina cf. straminea* attacking and eating a juvenile *Veronicella cubense*, National Botanical Garden, Havana province. Sequence 2: *Oleacina cf. straminea* feeding on *Coryda alauda*, Gran Piedra, Santiago de Cuba province. Sequence 3: *Oleacina cyanozoaria* eating a *Deroceras laeve* carnivorous semi slug, Pico San Juan, Cienfuegos province. Sequence 4: *Oleacina cyanozoaria* eating a *Eleutherodactylus* frog, Pico San Juan, Cienfuegos province. Photo credits by Adrián González-Guillén and Raymundo López-Silvero.





**Plate 2.** Pico San Juan (Saint John peak) área landscapes, Cienfuegos province. Photo credits by Rosario Dominguéz-Basail and Raymundo López-Silvero.



## New Species and Subspecies of Recent and Fossil *Amphidromus* Albers, 1850 from Java and Sumatra (Gastropoda: Camaenidae)

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**ABSTRACT** This paper presents two new species of subgenus *Amphidromus* Albers, 1850 and a new subspecies of subgenus *Syndromus* Pilsbry, 1900, all came from southern Sumatra, Indonesia; and a new fossil species of *Amphidromus* s.s. from Central Java, Indonesia.

**KEY WORDS** *Amphidromus*, *A. dancei*, *A. felixi*, *A. (Syndromus) porcellanus gistingensis*, *A. ubaldii*, Indonesia

### INTRODUCTION

Specimens of the first new species of subgenus *Amphidromus* Albers, 1850 were collected by a native man from Lahat Regency, South Sumatra Province. Shells are large, dextral or sinistral; and comparable with *A. javanicus* (Sowerby, 1841) from western Java and *A. puspa* Dharma, 1993 from central Sumatra.

The second new species of *Amphidromus* s.s. described is based on two dead collected shells, both dextral, found near the shoreline in South Bengkulu Regency, Bengkulu Province, Sumatra. Shell outline is ovate elongate with a slight prolongation of the columellar margin, which distinguishes it from other species of *Amphidromus* s.s. and comparable with *A. (Syndromus) beccarii* Tapparone-Canefri, 1883 from South Sulawesi. The shells were previously used by hermit crabs, suggesting that the habitat of the snail is close to the beach.

In this paper, a new record of *Amphidromus (Syndromus) porcellanus porcellanus* (Mousson, 1848) is reported from Belitung Island, off southeastern Sumatra. The new subspecies of *A. (S.) porcellanus* is distinguished from the nominate subspecies by having some character differences such as: slightly more robust and

somewhat thicker shell, apex not black, and no radial pattern on the last whorl. Specimens of the new subspecies came from the southwestern part of Lampung Province, South Sumatra, and have a different locality from the nominate subspecies.

The new fossil species of *Amphidromus* s.s. is from Sangiran, Central Java, Late Pliocene; all seven specimens examined are dextral. The shell is small compared to the other species of the subgenus, shell height 31.9-34.9 mm, comparable with the fossil species *A. sangiranensis* Dharma, 2007 that also comes from Sangiran, Central Java and *A. alticola* Fulton, 1896 from West Java.

### ABBREVIATIONS

- MZB Museum Zoologicum Bogoriense,  
Cibinong, Bogor, Indonesia  
SMF Senckenberg Forschungsinstitut und  
Naturmuseum, Frankfurt, Germany  
BD Bunjamin Dharma's collection

h = height, d = diameter, ha = height of aperture,  
hlw = height of last whorl.



## SYSTEMATICS

- Family : Camaenidae Pilsbry, 1895  
 Subfamily : Camaeninae Pilsbry, 1895  
 Genus : *Amphidromus* Albers, 1850  
 Subgenus : *Amphidromus* Albers, 1850; type species: *Helix perversa* Linnaeus, 1758  
 Subgenus : *Syndromus* Pilsbry, 1900; type species: *Helix contraria* Müller, 1774

*Amphidromus dancei* Dharma, new species  
 (Figures A, B, 1-3)

**Description.** Shell moderately large, up to 59.1 mm, dextral or sinistral, high conical or rather ovate conical, thick, a little transparent and slightly polished. Whorls  $5\frac{3}{4}$ - $6\frac{3}{4}$ , regularly increasing in size and slightly convex. Apex white, smooth and shiny. Suture shallow, somewhat crenulated by terminations of rather coarse radial rugae; spiral sculpture very weak. Ground color yellow, last whorl decorated with irregularly spaced radial brown stripes that reach the suture, and bold radial brown stripes that mark growth-arrests. Aperture ovate, oblique and pale yellow to yellowish gray inside, showing external stripes. Perch angle  $26^{\circ}$ - $35^{\circ}$ . Parietal callus thin and colorless, sometimes whitened at the margin. Peristome not continuous, white; outer lip expanded, thickened and recurved; columella thick, vertical. Umbilicus nearly closed, partially concealed by a folded and broadened columellar margin.

Measurements: h = 54.8-59.1 mm, d = 29.9-33.1 mm, ha = 30-34 mm, hlw = 40.8-44.3 mm, h/d = 1.68-1.98, ha/h = 0.53-0.59, hlw/h = 0.72-0.77.

Animal body light gray, reticulated, the recessed parts grayish brown, head orange, foot orange

then gray and whitish on the edges, tentacles grayish brown, eyes transparent light cream.

**Type Material.** Holotype MZB Gst. 22.030, h = 54.8 mm; 3 paratypes MZB Gst. 22.031, h = 57.7 mm, 58.6 mm and 45.1 mm (juvenile); 3 paratypes SMF 363005, h = 56.3 mm, 58.5 mm and 46.4 mm (juvenile); 4 paratypes BD, h = 59.1 mm, 55.3 mm, 57.7 mm and 55.2 mm.

**Type Locality.** Lahat Regency, South Sumatra Province, Indonesia.

**Distribution.** Only known from the type locality.

**Habitat.** On trees in the forest.

**Etymology.** Named after Peter Dance, England.

**Discussion.** *Amphidromus dancei* n. sp. differs from *A. javanicus* and *A. puspae* by having a more expanded outer lip. In comparison, *A. javanicus* from Java on average has a larger shell with height up to 67 mm, ground color is white or yellowish, and the umbilicus is usually closed. In comparison, *A. puspae* has high conical shell with fine radial rugae, decorated with radial lines and no radial stripes or streaks, parietal callus is dark brown or purplish brown, and the umbilicus is closed or nearly closed. Two live taken specimens of *A. dancei* n. sp. consisting of one adult (Figure A, apex broken) and one juvenile (Figure B), are still alive when this paper was written (paratypes, BD).

*Amphidromus felixi* Dharma, new species  
 (Figures 4-5)

**Description.** Shell moderately large, up to 56 mm, dextral, ovate elongate and conical to apex, rather slender, of medium thickness and a little transparent. Apex and spire sculptures slightly abraded. Whorls about  $6\frac{1}{2}$ , with quite



different degrees of whorl increment, whorls slightly convex; spire short. Last whorl elongated, somewhat inflated near suture and sub-rectangular, height about three-quarters of total shell height. Suture shallow, somewhat crenulated by terminations of coarse radial rugae; spiral sculpture very weak. Ground color white, brown growth-arrest stripes possible, subsutural zone whitish. Aperture ovate elongate, height about half of the shell height, oblique, white inside. Perch angle  $24^{\circ}$ - $26^{\circ}$ . Parietal callus rather thick, white or thin, colorless. Peristome not continuous, white; outer lip expanded, thickened and recurved; columella thick, vertical, and its insertion with a slight prolongation. Umbilicus open or nearly closed, partially concealed by a folded and broadened columellar margin.

Measurements:  $h = 56$  mm, 54.8 mm;  $d = 27$  mm, 25.8 mm;  $ha = 28.2$  mm, 29.6 mm;  $hlw = 40.2$  mm, 42 mm;  $h/d = 2.12$ , 2.15;  $ha/h = 0.51$ , 0.53;  $hlw/h = 0.73$ , 0.75.

**Type Material.** Holotype MZB Gst. 22.032,  $h = 56$  mm; paratype BD,  $h = 54.8$  mm.

**Type Locality.** Near coast in South Bengkulu Regency, Bengkulu Province, Sumatra, Indonesia.

**Distribution.** Only known from the type locality.

**Habitat.** The two shell specimens of *A. felixi* n. sp. were found by a hermit crab collector in South Bengkulu Regency, Bengkulu Province, Sumatra. Those shells were found inhabited by the hermit crab *Coenobita cavipes* Stimpson, 1858 near the shoreline; these crabs can roam quite far into the forest, up to 500-1,000 m from the shoreline. Perch angle of *A. felixi* n. sp. is small,  $24^{\circ}$ - $26^{\circ}$ , indicating that the snails like to perch on leaves.

**Etymology.** Named after Felix Wang of Jakarta, Indonesia.

**Discussion.** *Amphidromus felixi* n. sp. differs from other species of *Amphidromus* s.s. by having quite different degrees of whorl increment, last whorl elongated and somewhat inflated near the suture, aperture ovate elongate, spire short, and perch angle small. This new species of *Amphidromus* s.s. is comparable with the sinistral and slender shells of *A. (S.) beccarii* from South Sulawesi. Shells have a similar shape, sculpture and columella, some may have a columellar prolongation (Laidlaw and Solem, 1961; figure 30). Measurements of two *A. (S.) beccarii* specimens from South Konawe, South Sulawesi:  $h = 42.5$  mm, 44.5 mm;  $d = 20.7$  mm, 19.2 mm;  $ha = 21.5$  mm, 22 mm;  $hlw = 30.2$  mm, 31.5 mm; perch angle  $36^{\circ}$ ,  $30^{\circ}$ ;  $h/d = 2.05$ , 2.32;  $ha/h = 0.51$ , 0.49;  $hlw/h = 0.71$ , 0.71.

*Amphidromus (Syndromus) porcellanus*  
*porcellanus* (Mousson, 1848)  
 (Figures 12-16, D image on the right)

**Description:** Shell small, up to 32 mm, sinistral, slender, thin, transparent and smooth. Whorls 6-7, regularly increasing in size, slightly convex. Apex dark brown to black, smooth and shiny. Suture shallow, somewhat crenulated by terminations of fine radial rugae; spiral sculpture very weak. Ground color cream or straw yellow, last whorl decorated with radial brown streaks or flames that vary in number, about 10-23; streaks divided at the periphery of each whorl and do not reach the suture, a pale spiral zone along the upper part of each whorl, and a yellow line or band below suture. Two brown spiral bands below periphery on the last whorl, a pale area around umbilicus. Aperture oblique, ovate; white inside with external brown streaks and spiral bands visible. Perch angle



27°-30°. Parietal wall overlaid by thin callus. Peristome not continuous, white; outer lip slightly expanded, a little thickened and weakly reflected; columella rather thick, almost vertical. Umbilicus slightly open or nearly closed, partly concealed by a folded and broadened columellar margin.

Measurements:  $h = 22.4\text{-}32\text{ mm}$ ,  $d = 12\text{-}15\text{ mm}$ ,  $ha = 10.2\text{-}13.8\text{ mm}$ ,  $hlw = 15.1\text{-}20\text{ mm}$ ,  $h/d = 1.85\text{-}2.19$ ,  $ha/h = 0.41\text{-}0.48$ ,  $hlw/h = 0.60\text{-}0.69$ .

**Material Examined.** Banten Province (Western Java): Bojong, near Saketi; near Malimping. West Java Province: near Sukabumi; Kadudampit, Sukabumi; Bogor; Ciseeng, near Depok (dead taken); near Plered (dead taken); and Pawon Cave, Padalarang (dead taken). Lampung Province: Kotabumi; Way Kanan, Tulang Bawang Regency; and Sribawono. South Sumatra Province: near Baturaja; Blambangan, southwest of Baturaja; and Lahat Regency. Bangka Belitung Islands Province: Petaling, Mendo Barat, Bangka Island; Nibung, Puding Besar, Bangka Island; and Gunung Tajam, Belitung Island (fragment).

**Type Locality.** Java, Indonesia.

**Distribution.** Banten Province including Krakatau and Sebesi Islands, Sunda Strait between Java and Sumatra; West Java Province; Lampung Province; South Sumatra Province; and Bangka and Belitung Islands Province off southeastern Sumatra (see Map 1, marked as triangles on the geographical distribution map).

**Habitat.** On various trees, such as on banana leaves and coconut trees; also, coffee, pepper and bamboo plantations.

**Discussion.** The largest specimen examined is 32 mm in height, less than the largest recorded (34 mm) by van Benthem Jutting (1950; p. 493).

All specimens examined have dark brown to black apex. Three specimens from near Malimping, West Java have no brown radial streaks or flammules on the last whorl. A fragment of *A. (S.) p. porcellanus* was collected from the slope of Gunung Tajam, Belitung Island, southeast of Sumatra, and this is a new record for this species. A specimen of *A. (S.) p. porcellanus* was collected from Lahat Regency, South Sumatra Province, which is the northernmost place where this species can be found in Sumatra.

*Amphidromus (Syndromus) porcellanus*  
*gistingensis* Dharma, new subspecies  
(Figures 7-11, D image on the left)

- *Amphidromus porcellanus* - Dharma, 1987: p. 12, Fig. 2, no. 3.
- *Amphidromus (Syndromus) porcellanus* - Dharma, 1992: p. 118, pl. 37, fig. 8d, 8e.
- *Amphidromus (Syndromus) porcellanus* - Dharma, 1998: p. 8-9, fig. right.
- *Amphidromus (Syndromus) porcellanus* - Dharma, 2005: p. 234, pl. 92, no. 8c.

**Description:** Shell rather small, up to 33.3 mm, sinistral, high conical, rather thin and smooth. Whorls  $5\frac{1}{2}\text{-}6$ , regularly increasing in size and slightly convex. Apex whitish, smooth and shiny. Suture shallow, somewhat crenulated by terminations of fine radial rugae, and a yellow line below suture; spiral sculpture very weak. Ground color cream or straw yellow, some earlier whorls gray or ash-colored. Third, fourth, and fifth whorls usually with radial brown streaks or flammules, divided at the periphery; about 10 streaks on the fourth whorl. Last whorl has a monochrome straw yellow zone without streaks above the periphery, two spiral brown bands below the periphery and a pale area around umbilicus. Aperture oblique, ovate, white inside with two spiral brown bands visible. Perch angle 25°-30°. Parietal wall overlaid by thin callus. Peristome not continuous, white;



outer lip slightly expanded, a little thickened and weakly reflected; columella rather thick, almost vertical. Umbilicus open or nearly closed, partially concealed by a folded and broadened columellar margin.

Measurements:  $h = 24.3\text{--}33.5$  mm,  $d = 13.7\text{--}18.9$  mm,  $h_a = 11.7\text{--}18.2$  mm,  $hlw = 16.6\text{--}21.5$  mm,  $h/d = 1.77\text{--}2.03$ ,  $h_a/h = 0.46\text{--}0.64$ ,  $hlw/h = 0.65\text{--}0.68$ .

**Type Material.** Gisting, Lampung Province: holotype MZB Gst. 22.033,  $h = 30.1$  mm; 1 paratype MZB Gst. 22.034,  $h = 28.9$  mm; 1 paratype SMF 363006,  $h = 29.2$  mm; 1 paratype BD,  $h = 33.5$  mm. Umbulbaru, Pugung, Lampung Province: 1 paratype MZB Gst. 22.035,  $h = 29.4$  mm; 1 paratype SMF 363007,  $h = 28.5$  mm; 1 paratype BD,  $h = 32.6$  mm. Campangtiga, Kota Agung, Lampung Province: 1 paratype MZB Gst. 22.036,  $h = 29.1$  mm; 1 paratype SMF 363008,  $h = 24.3$  mm; 1 paratype BD,  $h = 29.2$  mm. Sumurtujuh, Wonosobo, Lampung Province: 1 paratype MZB Gst. 22.037,  $h = 29.8$  mm; 1 paratype SMF 363009,  $h = 30.6$  mm; 1 paratype BD,  $h = 29.2$  mm.

**Type Locality.** Gisting, Lampung Province, southern Sumatra, Indonesia.

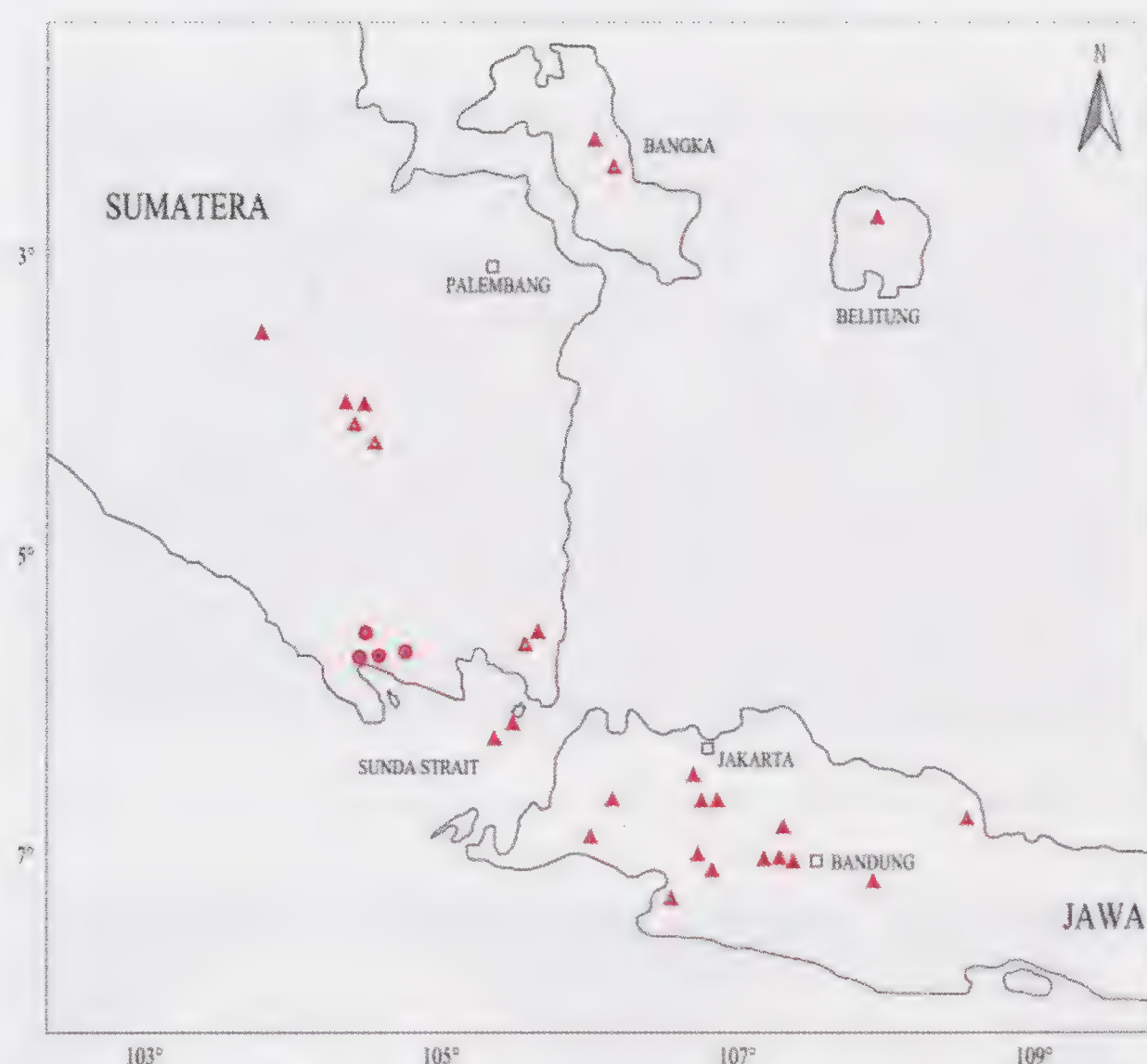
**Distribution.** Southwestern part (Tanggamus Regency) of Lampung Province, southern Sumatra, Indonesia (see Map 1. Marked as circles on the geographical distribution map).

**Habitat.** On leaves of banana plants, and various trees.

**Etymology.** Named after the type locality of this new subspecies.

**Discussion.** Of all the *A. (S.) porcellanus gistingensis* n. ssp. specimens examined, the apex is whitish and not dark brown or black as

seen on *A. (S.) p. porcellanus*, and the above the periphery on the last whorl has monochrome straw yellow color without streaks. In comparison with the nominate subspecies, shells of *A. (S.) p. gistingensis* n. ssp. are less slender, relatively thicker and slightly more robust with a slightly larger aperture. *A. (S.) p. gistingensis* n. ssp. was not found in the same location as *A. (S.) p. porcellanus* (see the geographical distribution map). Both *A. (S.) p. porcellanus* and *A. (S.) p. gistingensis* n. ssp. have never been found in the same location as *A. (S.) sumatranus* (von Martens, 1864) or *A. (S.) elvinae* Dharma, 2007.



**Map 1.** Geographical distribution map of *A. (S.) p. porcellanus* (triangle) and *A. (S.) p. gistingensis* n. ssp. (circle).

*Amphidromus ubaldii* Dharma, new species  
(Figures 17-19)

**Description:** Shell small, height up to 34.9 mm, dextral, high conical or rather ovate conical with inflated last whorl, rather thin, not or little transparent, shining; spire somewhat tapering to apex. Whorls  $5\frac{1}{2}$ –6, regularly increasing in size, some earlier whorls somewhat convex, more convex on the last whorl. Apex smooth and



shiny. Suture shallow, somewhat crenulated by terminations of fine or rather coarse radial rugae; spiral sculpture very weak. Aperture oblique, ovate; parietal callus rather thick. Perch angle  $29^{\circ}$ - $31^{\circ}$ . Peristome not continuous; outer lip expanded or slightly expanded, a little thickened and reflected; columella rather thick, vertical. Umbilicus open or nearly closed, partly concealed by a folded and broadened columellar margin.

Measurements:  $h = 31.9$ - $34.9$  mm,  $d = 16.1$ - $18.3$  mm,  $ha = 15.8$ - $17.2$  mm,  $hlw = 21.2$ - $23.9$  mm,  $h/d = 1.87$ - $2.06$ ,  $ha/h = 0.47$ - $0.53$ ,  $hlw/h = 0.64$ - $0.70$ .

**Type Material.** Holotype MZB Moll. Fos. 0064,  $h = 34.4$  mm; 1 paratype MZB Moll. Fos. 0065,  $h = 31.9$  mm; 2 paratypes SMF 363010,  $h = 33.1$  mm,  $33.7$  mm; 3 paratypes BD,  $h = 32.5$  mm,  $34.9$  mm,  $32.5$  mm (spire broken).

**Type Locality.** Sangiran, Central Java, Indonesia, Late Pliocene.

**Distribution.** Only known from the type locality.

**Etymology.** Named after Dr. Roberto Ubaldi, Italy.

**Discussion.** Shells of fossil *A. ubaldii* n. sp. are very small among the other species in the group of *Amphidromus* s.s., shell outline with somewhat tapering spire and inflated last whorl. In comparison, shells of fossil *A. sangiranensis*, also from Sangiran, have an ovate conical outline, more convex whorls, thick outer lip, closed umbilicus, and larger size on average with shell height  $33.5$ - $41.0$  mm. In comparison, the small sized recent species *A. alticola* from West Java has a shell with slightly more convex spire whorls and a closed umbilicus. Having found only dextral shells of *A. ubaldii* n. sp.,

raises the question of “does this species also have sinistral shells” because this new species was found in the same location as *A. sangiranensis*, which has dextral and sinistral shells. This description is only based on the seven dextral specimens collected; three of them incomplete. Additional specimens are required to confirm whether the sinistral form is present in this species.

## ACKNOWLEDGEMENTS

I am grateful to Mr. Peter Dance, England who gave me his famous book “Compendium of Seashells” at our meeting in June 1983 in Jakarta, Indonesia. I also thank Dr. Roberto Ubaldi, Italy for the opportunity and trust given to me to write the *Amphidromus* monograph. I also thank Mr. Felix Wang who provided the type materials of *Amphidromus felixi* n. sp. I also appreciate and thank the reviewers.

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Cite as: Dharma, B. 2021. New species and Subspecies of Recent and Fossil *Amphidromus* Albers, 1850 from Java and Sumatra (Gastropoda: Camaenidae). The Festivus 53(4):298-306. <https://doi.org/10.54173/F534298>



**Figure A.** *Amphidromus dancei* n. sp. paratype BD.



**Figure B.** Juvenile *Amphidromus dancei* n. sp. paratype BD.

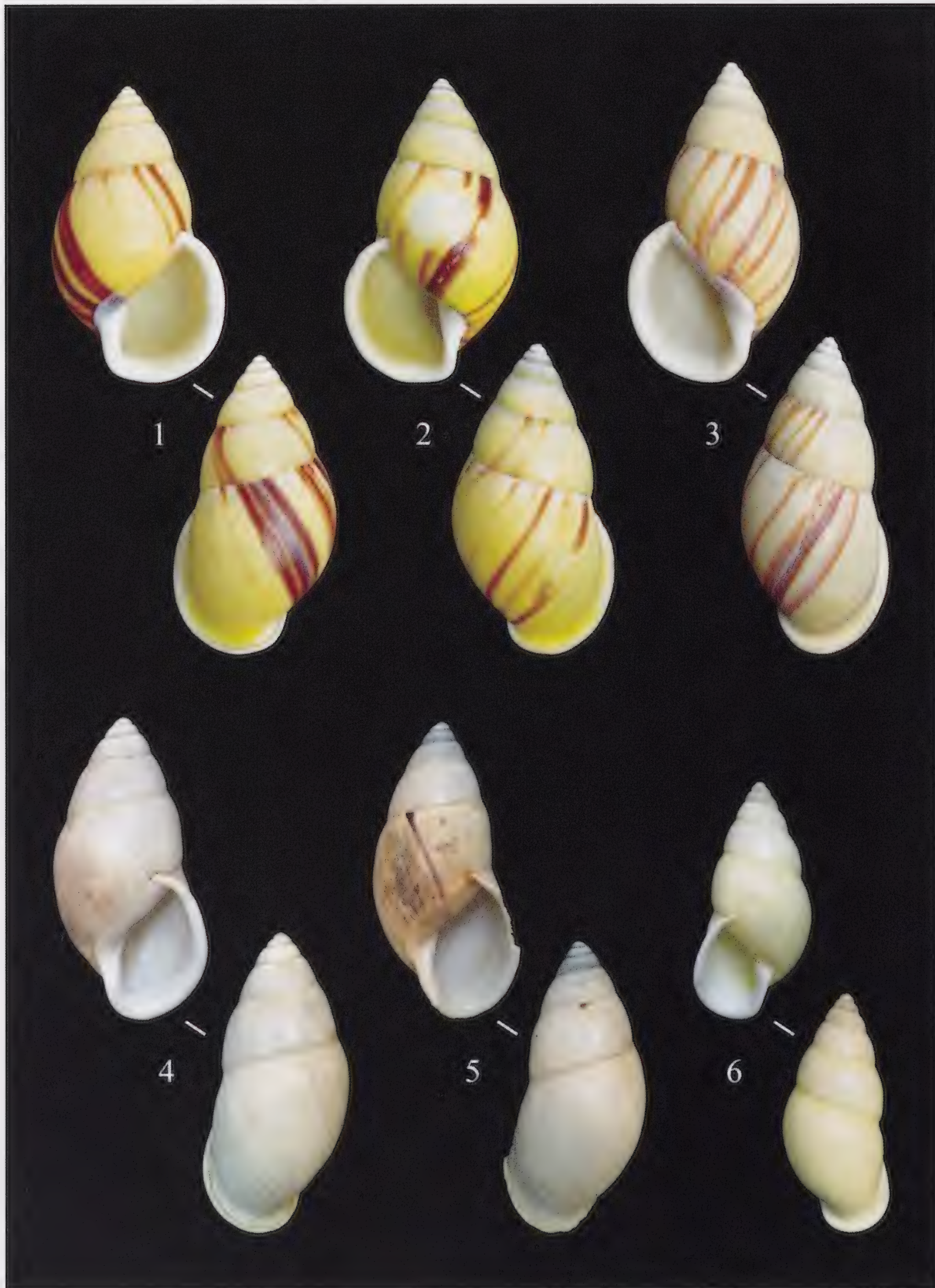


**Figure C.** *Amphidromus puspa* holotype MZB Gst. 9467.



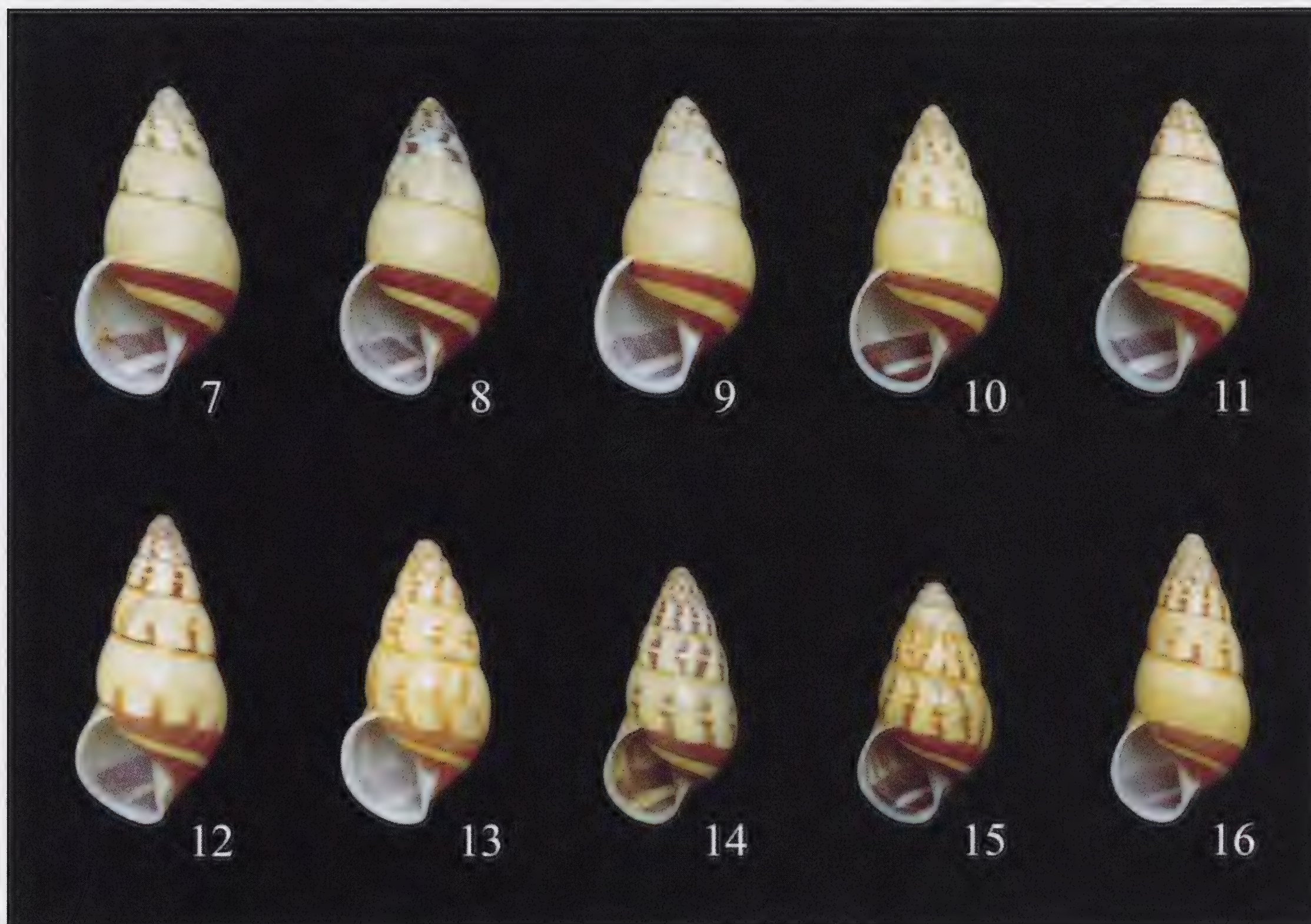
**Figure D.** Apex detail. Left: *A. (S.) p. gistingensis* n. ssp.; Holotype, Gisting, Lampung, Sumatra. Right: *A. (S.) p. porcellanus*; near Malimping, West Java.





**Figures 1-3.** *Amphidromus dancei* n. sp. Lahat Regency, South Sumatra Province: 1. Holotype MZB Gst. 22.030, h = 54.8 mm; 2. Paratype SMF 363005, h = 56.3 mm; 3. Paratype BD, h = 59.1 mm. **4-5.** *A. felixi* n. sp. coast in the South Bengkulu Regency, Bengkulu Province, Sumatra: 4. Holotype MZB Gst. 22.032, h = 56 mm; 5. Paratype BD, h = 54.8 mm. **6.** *A. (S.) beccarii* South Konawe, South Sulawesi, h = 42.5 mm.





**Top row: Figures 7-11.** *Amphidromus (S.) porcellanus gistingensis* n. ssp.: **7.** Holotype MZB Gst. 22.033, Gisting, Lampung, h = 30.1 mm; **8.** Paratype MZB Gst. 22.036, Campangtiga, Kota Agung, Lampung, h = 29.1 mm; **9.** Paratype SMF 363006, Gisting, Lampung, h = 29.2 mm; **10.** Paratype SMF 363007, Umbulbaru, Lampung, h = 28.5 mm; **11.** Paratype BD, Sumurtujuh, h = 29.2 mm.  
**Bottom row: 12-16.** *A. (S.) p. porcellanus*: **12.** near Sukabumi, West Java, h = 31 mm; **13.** Kotabumi, Lampung, h = 28.9 mm; **14.** Sribawono, Lampung, h = 26 mm; **15.** Nibung, Bangka, h = 24.6 mm; **16.** near Malimping, West Java, h = 29.4 mm.



**Figures 17-19.** *Amphidromus ubaldii* n. sp. Sangiran, Central Java, Late Pliocene: **17.** Holotype MZB Moll. Fos. 0064, h = 34.4 mm; **18.** Paratype SMF 363010, h = 33.1 mm; **19.** Paratype BD, h = 32.5 mm. **20.** *A. sangiranensis*, h = 35.5 mm.





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We are interested in all types of shells, marine or land and all genera and species, including books on shells as well as items related to shells such as artwork, storage cases and tools. Your donated items will be used to generate income to support the Club's efforts in continuing Public education about shells and conservation of marine life throughout the world. If you would like to donate, please contact David Waller, SDSC Acquisition Chairperson, by email at [dwaller@dbwipmg.com](mailto:dwaller@dbwipmg.com) to schedule a time to discuss charitable gifting.

## **CLUB NEWS**

### **2021 - West Coast Shell Show**

Cancelled due to Covid-19 restrictions.

### **2021 August - General Meeting**

On August 28, 2021, the Club was treated to a Zoom presentation by Dr. Hans Bertsch on "Heterobranchia (Mollusca: Gastropoda) from Bahía de los Ángeles, Baja California: A Review of their Research History, Biodiversity, and Natural History". Here is a link to a video recording of the presentation:

[https://us02web.zoom.us/rec/play/mkxyYsz0yQJv4w4kGUr-REWdLoliCGA\\_NUnKifjDe3GIfQacyqwX-tWzoRmrED920VluQegFvcj6Xfm.uwiLafji7OA4uTS6?autoplay=true&continueMode=true&startTime=1630192039000](https://us02web.zoom.us/rec/play/mkxyYsz0yQJv4w4kGUr-REWdLoliCGA_NUnKifjDe3GIfQacyqwX-tWzoRmrED920VluQegFvcj6Xfm.uwiLafji7OA4uTS6?autoplay=true&continueMode=true&startTime=1630192039000)

### **2021 September Party**

Cancelled due to Covid-19 restrictions.

### **2021 October - General Meeting**

Cancelled due to Covid-19 restrictions.



## Editor's Corner

David P. Berschauer

1385 12<sup>th</sup> Avenue NW, Cairo, Georgia 39828

[shellecollection@hotmail.com](mailto:shellecollection@hotmail.com)

The Editorial Board is working on moving The Festivus into the modern era. Over the last year or two I have been hearing more and more about **journal impact factors**. This is a quasi scientific index of how much a journal is cited, *i.e.* articles published in our journal being cited in other articles (in our journal or others). This is a relatively new metric, but has almost completely taken over academia. In the past 8 to 10 years a handful of new ejournals have pretty much taken over publishing by commandeering high "IF" or "JIF" scores through a number of methods.

(See [https://en.wikipedia.org/wiki/Impact\\_factor](https://en.wikipedia.org/wiki/Impact_factor) and <https://researchguides.uic.edu/if/impact>) As it turns out most older journals do not have an "IF" or "JIF" score at all because they have never registered and gotten into this modern system.

Question: Why should we do this? Having a score helps attract scientists to publish in one's journal, as most universities actively discourage their professors from publishing in journals which do not have a scoring. The short of the matter is that getting into the system allows us to compete for more (and more impactful) articles, and will likely improve/increase membership among both institutions and professionals.

In November 2020 the Board unanimously voted to pursue registering The Festivus and taking the necessary steps to obtain an "impact factor", *i.e.* to move our journal into the 21<sup>st</sup> century.

Accordingly, we are undertaking this process to increase our journal's visibility to molluscan researchers throughout the world. The look and feel of our journal will remain the same but our authors will receive greater notoriety, their articles may be more widely read, and we should see an increase in our membership.

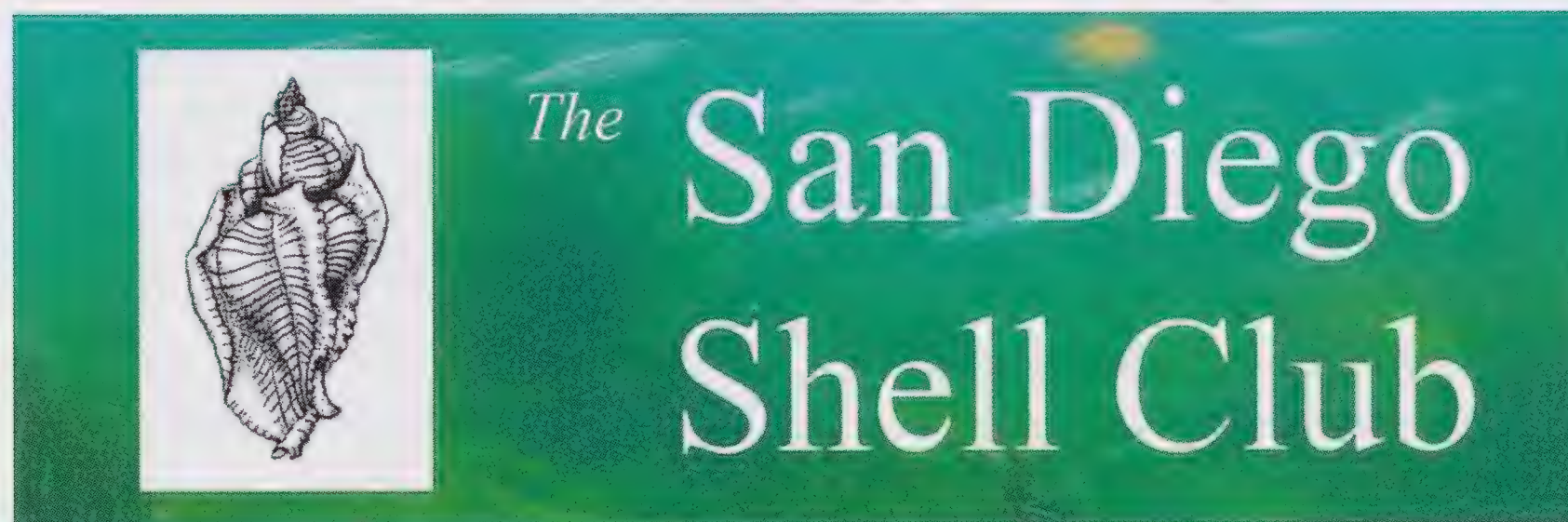
Part of the process involves registering the journal with CrossRef, obtaining DOIs (digital object identifiers) for all individual articles (note the [blue hyperlinks](#) at the end of the literature cited section for each article), and uploading a PDF to our website for each peer reviewed article. Once the articles can be traced through their unique DOIs the number of articles referencing them can be identified by the third party (here CrossRef). Finally, registration with a third party Impact Factor organization which will calculate and publish the journal's impact factor. In simple terms what this does is tells others how often our articles are cited by others. The goal of this exercise is to allow all peer reviewed articles published in The Festivus to be more visible to molluscan researchers and to increase visibility in the community.

We are in the process of adding additional members to our Editorial staff to assist us in moving the journal forwards, including Assistant Editor-in-Chief, Research Editor, Associate Editor, and we currently have an opening for Copy Editor. As the old saying goes "more hands make lighter work."



## San Diego Shell Club: Streamlining Operations- Part II

David B. Waller and Robyn Waayers



The San Diego Shell Club is pleased to present our new website designed by our new webmaster, Robyn Waayers, as part of our new streamlining of the Club's operations. With the help of Dr. Paul Tuskes and the Board, Robyn was able to create the next generation of the Club's website for our ever growing Internet presence. Our new website utilizes a user friendly website building program that allows modifications to be made more easily to support our future growth. Much of the content of the original site has been replicated in the new site and some new features have been added.

Some of those new features include:

- more Southern California-specific images, from the photographic libraries of Robyn Waayers and Dr. Paul Tuskes;
- a brand new section titled "SHELLS!" in the Marquis includes a "Photo Gallery of Southern California Mollusks", information about *Haliotis rufescens*, California's proposed state mollusk, and information about protected areas and regulations relevant to mollusks in California. The photo gallery is a work-in-progress and will be developed over time, with more species and biological information to be added;
- a new page titled "Shell Club Presentations" under "RESOURCES" in the Marquis provides video-taped presentations of our General Meetings that can be viewed at your convenience if you were unable to attend the presentation;
- a new page titled "Information about Protected Areas and Regulations" under "SHELLS!" in the Marquis provides specific information of interest that when selected will redirect the reader to websites containing that information; and
- a new page titled "How to Become a Member" under "MEMBERSHIP" in the Marquis provides an easy step-by-step process to become a member of the San Diego Shell Club.

A general announcement was sent to the Club's membership and posted on the Club's Facebook page, about the new site's debut. We will be posting a few reminders regarding the replacement of our old website over the next few months. So, bookmark and/or save the new site's web address, <https://www.thesandiegoshellclub.com>.

Celebrate with us. Tell your friends, family and colleagues about our new website. If you have ideas on how we can improve the Club's website, please let us know [rwaayers@gmail.com](mailto:rwaayers@gmail.com).



## Repurposing Seashells

David B. Waller

Recently, the San Diego Shell Club was offered a donation of a large collection located here in San Diego. It was a dealer's stock, formerly known as Naylor Seashells. The shells had been stored outside on the property (see Figures 1, 2 and 8), in the garage (see Figures 3-5) and under the house for a few decades (see Figures 5 and 6).



Figures 1 and 2. Shells stored outside on the property.

The condition and volume of the shells was such that the SDSC could not accept the donation. There were literally enough shells to fill a significant portion, if not an entire, metal storage container that they use for overseas shipping. Many of the shells had been exposed to the weather and were in poor condition, those stored in containers in the garage and under the house were in better condition, but almost all were not of specimen quality and not sellable without substantial cleaning. The owner did not want to discard them but the site is being raised for a new home. So what can be done with the shells? Repurpose them!

As collector's we are always looking for the perfect shell and sometimes lose sight of the fact that when we began collecting shells, condition was not as important as having a shell of that species. Over time as our collections grew and more resources were available, we are able to find and pay for those, "more-perfect", shells. But beginning shell collectors are not so concerned about that chip, scratch, or growth flaw and would be pleased to have many of the shells we would simply discard like many in this collection.

Historically, some of the local species, such as *Haliotis cracherodii* (Black abalone) and *H. sorensenii* (White abalone), were harvested almost to extinction and are now listed as endangered species. Because they were so aggressively harvested, their shells are not rare and can be found in most collections, but can no longer be sold. The Naylor Seashells collection had a large number of abalones that had been collected from around 1970 through the 1980's (see Figure 8). Many were



likely discarded shells from the harvesting companies as evidenced by the pried bar chips along their edges, a common method used at that time to remove them from rocks. While most of these shells are not collector quality, they would be welcomed gifts for beginning collectors.



Figures 3, 4 and 5. shells stored in the garage.



Figures 8. Shells on roof of garage.

Whether one believes or does not believe, it is clear that our global environmental conditions are changing. Areas of the oceans around the world are experiencing changes in temperature, pH and pollution. Higher water temperatures have resulted in the bleaching of corals, a key food source for many reef fish, pH changes interfere with the chemical reaction involved with calcium carbonate deposition preventing mollusks from forming healthy shells and when the sediment on the ocean floor (that builds up from human waste released into the ocean) is churned up during a storm, it creates a nutrient rich environment for bacterial growth, resulting in massive blooms, known as “red tides”. When these bacteria begin to die they release toxins that can kill fish and other marine life.



Because of these conditions, the shells that we collect today are not the quality that used to be collected only a decade ago. Since many of the Naylor seashells were collected in the 1970's-80's, the mature specimens have good weight and structure and would be a great addition to a new collection.

We face many challenges as a species. Understanding our natural world and inspiring future generations to become involved in addressing and solving these challenges should be one of our generation's most important objectives. With the volume of shells that have been collected over the centuries, there are more than enough to go around. It's time to repurpose those specimens that many might consider less desirable, utilizing them to generate interest in the children of today with the hopes of developing future oceanographers, malacologists, conchologists and the like. Repurposing these shells accomplishes this goal as well as reducing the desire to harvest large volumes of mollusks in the future (see Figure 9).



**Figure 9.** For the children.



## Seizure and Forfeiture

### United States Fish and Wildlife Service and The Endangered Species Act of 1973, Part III

David B. Waller  
505 North Willowspring Drive, Encinitas, California 92024  
[dwaller@dbwipmg.com](mailto:dwaller@dbwipmg.com)

In Part II of this three part series, I discussed conversations with Inspector Yashuda regarding the USFWS Notice of Seizure and Proposed Forfeiture that culminated in the preparation of a Petition for Remission, FOIA requests submitted to the USPS and USFWS and notification letters to Senators Dianne Feinstein, Alex Padilla and Thomas Carper. It was the Inspector's cavalier attitude about the USFWS' belief that they could seize any property from the U.S. mail and claim it forfeit that inspired my actions to explore deeper and shine a light on the powers granted this Agency and their procedural implementation of those powers as they apply to the Endangered Species Act. It seems clear that a lack of transparency in the implementation of those powers is problematic for the Agency.

In this Part, I discuss the results of the process I used to recover my property and what others can do to avoid seizures.

While the process I used seemed to work; meaning my property was returned, many questions that were raised still remain unanswered:

- How could the USFWS have made this error in identifying two relatively common shells as endangered species?;
- How was I in violation of the Endangered Species Act when the shells were not endangered species?;
- What authority granted the USFWS, under the Endangered Species Act, allows seizures and confiscations of non-threatened or endangered species with impunity?; and
- How does the Environment and Public Works Committee enforce its oversight authority over the Agency to protect the rights of U.S. citizens?

I suppose the answer could be; "It's a government agency!". While I do not agree with this statement, I suspect that there are many other agencies with similar problems.

What seems to be clear is:

- The Endangered Species act covers, a number of species that have been investigated and determined to be subject to extinction unless protected (*i.e.*, a complete listing is available on the Internet);
- Special powers have been granted the USFWS under the Endangered Species Act to enforce laws to protect endangered species (16 U.S.C. §1538);
- Searches and seizures may not require a warrant (445 FW1, section 1.3(E)). However, they always require "probable cause" (445 FW1 Section 1.4(D));
- Violation of the Endangered Species Act applies to individuals engaged in "business as an importer or exporter of fish and wildlife" (species covered under the Endangered Species Act) who



have not filed for a license. However, no license is required for a “collector or hobbyist” who collects species, not listed as endangered, for “personal use” (50 C.F.R. §14.91);

- The USFWS can sell, non-endangered species, that have been seized and/or forfeit (Federal Register Vol. 81 June 17, 2016, §12.65(a)(4);

- Whoever knowingly and willfully obstructs or retards the passage of the mail, or any carrier or conveyance carrying the mail, shall be fined under this title or imprisoned not more than six months, or both (18 U.S.C. §1701); and

- Taking of property from another with the intent to permanently deprive them of it is theft under most state criminal statutes.



UNITED STATES POSTAL INSPECTION SERVICE  
OFFICE OF COUNSEL

- 2 -

July 2, 2021

Mr. David B Waller  
505 Willowspring Drive North  
Encinitas, CA 92024-1915

RE: FOIA No. 2021-FPIS-00372

Dear Mr. Waller:

This is in reference to your letter dated May 6, 2021, requesting, pursuant to the Freedom of Information Act, access to certain records that may be in the custody of the U.S. Postal Inspection Service regarding the following:

1. Any and all documents forwarded to the USFWS and/or Inspector Yashuda regarding USFWS Office of Law Enforcement's Notice of Seizure and Proposed Forfeiture of the parcel, USFWS File Number: INV 2020804616.
2. Any and all images (e.g., X-ray images) and photographs forwarded to the USFWS and/or Inspector Yashuda regarding USFWS Office of Law Enforcement's Notice of Seizure and Proposed Forfeiture of the parcel, USFWS File Number: INV 2020804616.
3. Any and all documents supporting the USPS ISC's "probable cause" for diverting Addressee's parcel to the USFWS, USFWS File Number: INV 2020804616.
4. Any and all analyses and/or documentation created by the USPS ISC San Francisco Air Mail Center of the contents of the parcel, USFWS File Number: INV 2020804616, that justifies the decision to forward the parcel to the USFWS.
5. Any and all maintenance documentation demonstrating any and all equipment used to investigate Addressee's parcel (USFWS File Number: INV 2020804616) was maintained according to the manufacturer's procedure manual and USPS ISC policy and was in good working order when used to screen Addressee's parcel, USFWS File Number: INV 2020804616, before forwarding the parcel to the USFWS.

A search was conducted of the Postal Inspection Service records at National Headquarters. This search disclosed no records.

475 L'ENFANT PLAZA, SW, ROOM 3301  
WASHINGTON, DC 20260-2101  
TELEPHONE: 202-268-7084  
FAX: 202-268-4538

If you have any questions regarding the handling of your request, please contact the Inspection Service FOIA Requester Service Center at (202) 268-7004 between the hours of 8:30 a.m. – 5:00 p.m. (Eastern Time) or by email at [FOIA@usps.gov](mailto:FOIA@usps.gov).

If you consider this response to be a denial of your request for records, you have the right to appeal this response by writing to the General Counsel, U.S. Postal Service, 475 L'Enfant Plaza, SW, Washington, DC 20260-1135, within 90 days of the date of this response letter or via email at [FOIAAppeal@usps.gov](mailto:FOIAAppeal@usps.gov). Your appeal must be postmarked or electronically transmitted within 90 days of the date of the response to your request. The letter of appeal should include: (1) A copy of the request, any notification of denial or other action, and any other related correspondence; (2) The FOIA tracking number assigned to the request; (3) A statement of the action, or failure to act, from which the appeal is taken; (4) A statement identifying the specific redactions to responsive records that you are challenging; (5) A statement of the relief sought; and (6) A statement of the reasons why you believe the action or failure to act is erroneous.

Additionally, you may contact the Office of Government Information Services (OGIS) which was created to offer mediation services to resolve disputes between FOIA requesters and Federal agencies as a non-exclusive alternative to litigation. Using OGIS services does not affect your right to pursue litigation. You may contact OGIS in any of the following ways: write to the Office of Government Information Services, National Archives and Records Administration, 8601 Adelphi Road-OGIS, College Park, MD 20740-6001; email to [ogis@nara.gov](mailto:ogis@nara.gov); call (202) 741-5770 (toll-free (877) 684-6448); fax to 202-741-5769.

Sincerely,

Anastasia M. Washington  
FOIA Analyst

**Figure 1.** Letter from the USPS indicating that no documents were identified.

A couple of weeks after filing the Declaration to accompany my Petition for Remission, I received a call from the Inspector informing me that my petition had been granted and that my property would be returned. Shortly after that conversation, I received notification from the USFWS that my FOIA request had been denied. The exception stated for the agency's denial was because this was an “ongoing investigation”. But how can there be an ongoing investigation when my petition was granted? This denial was appealed. Some weeks later, I also received a communication from the USPS stating that they had “no information” regarding my parcel and therefore could not answer



any of the questions presented in my FOIA request (Figure 1). The appeal filed shortly after that decision was also denied. The letter concluded that:

“The reasonableness of a search is judged by the appropriateness of the methods used, not by the fruit thereof. Here, despite Ms. Washington’s search being fruitless, her methodology was appropriate under the circumstances. As such her actions on FOIA request 2021-FPIS-00372 are hereby affirmed in full.”

While this language seems like a judicial decision, it is not. The conclusions drawn by the USPS under this circumstance does not absolve them of responsibility nor liability.

USFWS Form 3-177 (Rev. 10/2017)  
OMB Control No. 1018-0012  
Expires 09/30/2019



U.S. FISH AND WILDLIFE SERVICE  
DECLARATION FOR IMPORTATION  
OR EXPORTATION OF  
FISH OR WILDLIFE

|                                                                                                                                                                                                   |                                                            |                                                                                                                                                                               |                                                             |                                                                                                                                                      |                                                         |                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|---------------------------------------------------------|
| 1. Date of Import/Export: (mm/dd/yyyy)                                                                                                                                                            |                                                            | 7. Name of Carrier:                                                                                                                                                           |                                                             |                                                                                                                                                      |                                                         |                                                         |
| 2. Import/Export License Number:                                                                                                                                                                  |                                                            | 8. Air Waybill or Bill of Lading Number:<br>Main: _____<br>House: _____                                                                                                       |                                                             |                                                                                                                                                      |                                                         |                                                         |
| 3. Indicate One: <input type="checkbox"/> Import <input type="checkbox"/> Export                                                                                                                  |                                                            | 9. Transportation Code: _____<br>Location: _____ State or Province: _____                                                                                                     |                                                             |                                                                                                                                                      |                                                         |                                                         |
| 4. Port of Clearance: _____                                                                                                                                                                       |                                                            | 10. Bonded Location for Inspection: _____                                                                                                                                     |                                                             |                                                                                                                                                      |                                                         |                                                         |
| 5. Purpose Code: _____                                                                                                                                                                            |                                                            | 11. Number of Cartons Containing Wildlife: _____                                                                                                                              |                                                             |                                                                                                                                                      |                                                         |                                                         |
| 6. Customs Document Number (s): _____                                                                                                                                                             |                                                            | 12. Markings on Cartons Containing Wildlife: _____                                                                                                                            |                                                             |                                                                                                                                                      |                                                         |                                                         |
| 13a. (Indicate One) (Complete name/U.S. address/telephone number/e-mail address)<br><input type="checkbox"/> U.S. Importer<br><input type="checkbox"/> U.S. Exporter                              |                                                            | 14a. (Indicate One) (Complete name/foreign address/telephone number/e-mail address)<br><input type="checkbox"/> Foreign Importer<br><input type="checkbox"/> Foreign Exporter |                                                             |                                                                                                                                                      |                                                         |                                                         |
| 13b. Identifier Number: _____ ID Type: _____                                                                                                                                                      |                                                            | 14b. Country Code: _____<br>14c. Identifier Number: _____ ID Type: _____                                                                                                      |                                                             |                                                                                                                                                      |                                                         |                                                         |
| 15a. Customs Broker, Shipping Agent or Freight Forwarder:<br>(Complete business name/address/telephone and fax number/e-mail address)                                                             |                                                            | 15b. Identifier Number: _____ ID Type: _____                                                                                                                                  |                                                             |                                                                                                                                                      |                                                         |                                                         |
| 15c. Contact Name: _____                                                                                                                                                                          |                                                            |                                                                                                                                                                               |                                                             |                                                                                                                                                      |                                                         |                                                         |
| Species Code<br>(000000-999999)                                                                                                                                                                   | 16a. Scientific Name<br>_____<br>16b. Common Name<br>_____ | 17a. Foreign CITES Permit Number<br>_____<br>17b. U.S. CITES Permit Number<br>_____                                                                                           | 18a. Description Code<br>_____<br>18b. Source Code<br>_____ | 19a. Quantity/Unit<br>_____<br>19b. Total Monetary Value<br>_____                                                                                    | 20. Country of Species Origin Code<br>(DDGGGG) 44254425 | 21. Venomous Live Wildlife Indicator<br>(000000-111111) |
|                                                                                                                                                                                                   |                                                            |                                                                                                                                                                               |                                                             |                                                                                                                                                      |                                                         |                                                         |
|                                                                                                                                                                                                   |                                                            |                                                                                                                                                                               |                                                             |                                                                                                                                                      |                                                         |                                                         |
|                                                                                                                                                                                                   |                                                            |                                                                                                                                                                               |                                                             |                                                                                                                                                      |                                                         |                                                         |
|                                                                                                                                                                                                   |                                                            |                                                                                                                                                                               |                                                             |                                                                                                                                                      |                                                         |                                                         |
| Knowingly making a false statement in a Declaration for Importation or Exportation of Fish or Wildlife may subject the declarant to the penalty provided by 18 U.S.C. 1001 and 16 U.S.C. 3372(d). |                                                            |                                                                                                                                                                               |                                                             | 22. I certify under penalty of perjury that the information furnished is true and correct:<br>_____<br>Signature Date<br>_____<br>Foreign Paper Name |                                                         |                                                         |
| For time/life only:<br>Action/Comments:<br><br><br>Wildlife Declared: <input type="checkbox"/> Yes <input type="checkbox"/> No<br><br>Wildlife Inspected:<br>None/ Partial / Full                 |                                                            | See Reverse Side of this Form for Required Notices                                                                                                                            |                                                             |                                                                                                                                                      |                                                         |                                                         |

Figure 2. USFWS importation/exportation declaration form 3-177.

And what about the letters sent to our representatives in Congress? I received Privacy Release forms from Dianne Feinstein’s office that requested an explanation of the problem, an outline of the steps taken, and the assistance requested for each of my communications with her Office; three release forms were submitted with the information requested. I also received three standard e-mail responses



from Senators Padilla and Carper. At this time, I have not been informed of any communications they may have sent to the USFW or USPS regarding this issue. However, I will keep you informed as that information comes in.

Based on my investigation of this case thus far, I can only speculate as to what happened. It appears that the parcel sent from Indonesia containing the two shells did not display the proper customs tag or the tag had been lost during transport. According to the documentation, this includes the addressee submitting a form 3-177 to the proper port of entry (*e.g.*, San Francisco or New York) prior to the parcel entering the United States (Figure 2). Because of this lack of documentation my parcel was likely separated for further investigation. Upon finding that the parcel contained sea shells (presumably by X-ray scanning) the USFIS redirected the parcel to the USFWS. Upon opening the parcel, no endangered species were identified. Instead of repackaging the shells and forwarding them to the addressee with a note indicating that the Indonesian shipper and the addressee had not provided proper documentation to the San Francisco Port of entry, the USFWS sent a letter of seizure and proposed forfeiture accusing the addressee of federal crimes. Such accusations are serious, so I filed a Petition for Remission and successfully argued for the return of my property. However, this was at great cost in both time and money.

It is clear that the process, as it was applied in this case, is broken. Once it was found that the shells were not endangered species, the parcel should have been immediately returned. Instead there was a significant amount of administrative work performed by the USFWS, a significant amount of time and money expended in defending the USFWS accusations including time spent by those who responded to my FOIA requests for the USFWS and the USFIS as well as staff involvement from the offices of Senators Feinstein, Padilla and Carper. This is an example of the United States Government at its worst. No endangered species were confiscated, no crimes were committed, the Agency's directive to enforce the Endangered Species Act was not achieved and nothing was done by the Agency to avoid these same issues arising in the future; avoiding unnecessary, unproductive, inefficient and ineffective use of taxpayer's money.

So what is the best approach that I can gather from this experience to help the readers in avoiding unnecessary contact with the USFWS?

1. Make sure that the shells being purchased are not endangered or threatened species. Check CITES Appendices I, II and III <https://cites.org/eng/app/appendices.php>;
2. When purchasing items from a foreign dealer, make sure they provide the proper documentation attached to the parcel from the country of origin;
3. Have the dealer provide comprehensive data slips; one for each shell (providing as much information about the shell as possible) in the parcel; and
4. Prior to the dealer shipping the shells, file a form 3-177 with the port of entry you expect will receive your parcel (San Francisco or New York). To answer the questions on completing the form (which are not at all clear), I recommend contacting the USFWS (Inspector Yashuda, (650) 876-9078) <https://www.fws.gov/le/pdf/3177.pdf>.



Another option to consider would be utilizing another mail delivery provider such as DHL, FedEx and UPS.

It is important to know that any time an individual receives a notification from a governmental agency that states you are “in violation of and in a manner unlawful of the laws and regulations of the United States...” and then proceeds to list the United States Codes that were supposedly violated, there should be an immediate response to those accusations. This is not a game! Without such a response those accusations stand, they can be brought up against you in the future and, in the worst case scenario, they can be presumed to be true if not denied. The government knows this, and anyone who has merely forfeited their shells in the past instead of confronting the USFWS is likely in the Agency’s database as a person of interest.

I hope this is helpful, not only to those who have interfaced with the USFWS in explaining some the issues you may have questioned, but also for those who intend to purchase shells from outside the country and import them into the United States.

If you have any questions, please contact me and tell me your story. It’s time to shed light on this system. With your stories, we can convince our representatives in Congress to fix the problem while at the same time strengthening the USFWS and our country’s objective to protect endangered species.



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## The “Cactus Man” and His Clams: Charles Russell Orcutt, *Coralliochama orcutti* and *Chlamydoconcha orcutti*

Hans Bertsch

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**ABSTRACT** Charles Russell Orcutt collected two species of clams some 65 miles and 75 million years apart. Both were named for him. One is a 70-75 million-year-old fossil he collected from Punta Banda, just south of Ensenada, Baja California, México, and the other is a living clam he collected from Mission Bay, San Diego, California. These are their stories.

### INTRODUCTION

During recent conversations with *The Festivus* Historian Dr. Paul Tuskes, we discussed the idea of periodic presentations of General Interest about rare, overlooked, wondered-about, or interesting regional mollusks. Orcutt’s clams struck me as an intriguing nexus in the history of San Diego’s peripatetic researchers and their equally peripatetic (*sensu lato*) research objects.

### CHARLES RUSSELL ORCUTT

Born and home-schooled on a farm in rural Vermont, young Charles was introduced to botany by his parents Heman Chandler and Eliza Eastin Gray Orcutt. His father was a farmer and horticulturist, and his mother, an accomplished poet and medical writer in her own right, shared her husband’s enthusiasm for plants. They moved with their sons Charles and John to San Diego in 1879, and Heman started a small nursery on land he bought near the ruins of Mission San Diego de Alcalá. The family collected plant specimens from the San Diego region for their nursery stock (Bullard, 1994, details these activities). Charles Orcutt made his first trip to Baja California at age eighteen.

He and his father joined a group of botanists on an expedition to Ensenada from 5-15 April 1882. “Charles, the youngest and least experienced of the group, accompanied the expedition as driver of the wagon that carried supplies for the camp and specimens collected along the way” (Bullard, 1994). The renowned botanists on the trip, Christopher Charles Parry, M. Eugene Jones, and Cyrus Guernsey Pringle, taught Charles how to collect, preserve, and catalog specimens for study. As Charles would later be honored, these three botanists have a number of southern California and Baja California plant patronyms, including the Baja California buckeye, *Aesculus parryi* Torrey; the quemador, or Jones Noseburn, *Tragia jonesii* Radcliffe-Smith & Govaerts; and the magnificent cardón (the world’s largest cactus, emblematic of the Baja California peninsula), *Pachycereus pringlei* (S. Watson) Britton & Rose (all three are illustrated in Rebman & Roberts, 2012).

Father and son continued collecting together until 1885. They meandered across the northern part of the peninsula, on their last collecting trip together, 22 June to 17 July 1885. Along the way Charles



became interested in shells and spent the rest of his life traveling and collecting cacti, other plants, and shells. In the *Baja California Travels of Charles Russell Orcutt*, Helen DuShane (1971: 33-37), quotes his account of that expedition (originally published by him in *The West American Scientist*, I (July-August 1885): 56-57), complete with his Tia Juana and Encenada misspellings and in his typical, uniquely personal impressions of what life was like on these journeys. Some selections:

JUNE 22, 1885. Leave the "quiet city by the sea," bid adieu to 'Uncle Sam,' and stay over night at 'Aunt Jane's' on Mexican soil.'

6-23. Take the wrong road and go to San Icedro.

6-24. Reach Ticate.

6-25. Most unfortunately, we step into the United States [without knowing it till afterwards].

6-27. Catch a pretty lizard marked with black and white stripes, the tail of a bright indigo blue. Another visits the tent and tries on my coat...Kill out last flea—can get no more until we reach Encenada, as they are not found on the mountains. Fling away the last tick also, as we have a rabbit for supper.

6-29. Go to Campo, U.S.A., thence to Nehi, drink a gallon of milk for supper, given us by Mr. Adams, 'the first man'—to visit these mountains.

6-30. Watch the men brand a lot of calves, and go a mile for the fun of cutting off both ends of a rattlesnake—the first, and last, for the trip. [He travels through the mountains, stopping at Hansen's Lagoon, then heads for Ensenada]

7-13. Find *Æsculus Parryi*, Gray, in bud, flower and fruit!

7-14. Pass through 'Purgatory' and camp at La Grulla, after a hard and unprofitable drive of twenty-four miles.

7-16. Reach the La Playa of S. Tomas where a few dead shells of *Haliotis rufescens* are found; and find great pools in the rocks lined with *thousands* of the purple-spined sea-urchins, forming one of the most beautiful sights imaginable.

7-17. Start for San Vicente and make a 'dry' camp—neither feed nor water for the horses. 7-18. Take the wrong road and go to San Jacinto, and find nothing except another, rather fine, verben. Find the road to S. Vicente is washed out and impassable. Remain over the 19<sup>th</sup>; the 20<sup>th</sup> start for San Diego, at La Grulla again the 21<sup>st</sup>, the 22<sup>d</sup> at Punta Banda, 23<sup>d</sup> at Encenada and Sauzal, and the 28<sup>th</sup> back at Aunt Jane's and Uncle Sam's.

His 22<sup>nd</sup> July stop at Punta Banda yielded the specimens of *Coralliochama orcutti*!

The year 1892 marked major turning points in Charles Orcutt's life. His father died, and he married Olive E. Eddy, a young doctor from Michigan. Dr. Olive Eddy lived with her sister in Pasadena, California, where she practiced medicine, and with her sister wrote and published a magazine titled *Out of Doors for Women*. They met through mutual friends. "For their wedding trip they rode horseback from Pasadena to San Jacinto, and then to San Diego, collecting plants the along the way. The couple settled in San Diego in one of several houses built by Orcutt and his brother at 21st and J streets. During the next six years they had four children" (Bullard, 1994).

"Charles Orcutt continued his expeditions and was away from his home much of the time. He attempted to make money selling parts of his collection and by running a small printing business, but Olive provided most of the financial support for the family through her medical practice" (Bullard, 1994), in addition to sending him funds while he was off exploring Texas, Arizona, Mexico and Central America. He spent his last years in the Caribbean, on the islands of Jamaica and Haiti, where he died of malaria.

Specimens Orcutt collected were deposited in several museums, including the San Diego Museum of Natural History and the Smithsonian Institution, where they are still being studied by various animal and plant taxonomists. A number of genera and species are named for him. The genus of grass, *Orcuttia* Vasey, 1886, was named to include the species *O. californica*, the type specimens of which had been collected by Orcutt near Bahía San Quintin. Another patronym, the Granite Spiny Lizard, *Sceloporus orcutti* Stejneger, 1893, was collected by Orcutt 5 January 1890 in Milquatay Valley, Campo, "just bordering the Mexican boundary, 50 miles east of San Diego by wagon road." This large rock dweller is known from southern California, throughout the peninsula to La Paz (excluding



the Cape Region, see Hall & Smith, 1979), and on many of the adjacent islands in the Gulf of California (McPeak, 2000). Among other vertebrates, there is a Jamaican frog, *Eleutherodactylus orcutti* Dunn, 1928, named for Orcutt. Although his obsessive collecting efforts resulted in lots of patronyms, Orcutt only named three gastropods, which are today not considered valid species. DuShane (1971) listed 18 species of mollusks named for him, although some have since been considered synonyms of earlier named species. Two of these are unique, interesting species, deserving of being highlighted. Both were named the type species of new genera.

### *Coralliochama orcutti* White, 1885

Charles A. White, M.D., named this species based on specimens sent to him by Orcutt from Todos Santos Bay (Punta Banda, Ensenada, Baja California, México), and less-well preserved specimens collected by G. F. Becker from Gualala, Mendocino County, California. Although separated by some 600 miles, White (1885) and Anderson (1902) regarded the strata at these two sites to be “equivalent,” *i.e.*, the same age. Anderson & Hanna (1935) reported a more southern occurrence, from “Johnson’s Ranch,” 15 miles south of El Rosario. Since then, the species has been recorded from several intermediate California localities, all west of the San Andreas fault: from Pigeon Point, San Mateo County; from the Nacimiento River drainage, Santa Lucia Range, Monterey County; in the Simi Hills, Chatsworth Formation, Los Angeles County; from the Schulz Member of the Williams Formation, Fremont Canyon, Santa Ana Mountains, Orange County; and from the Late Cretaceous formations at La Jolla and Point Loma, San Diego County (Fairbanks, 1893; Moore, 1968; Saul & Alderson, 1981; Elder & Saul, 1993; Squires & Saul, 2009). These strata are considered to be Late Campanian-Early Maastrichtian in age (Marincovich, 1975), approximately 70-75 million years ago, just a few million years before the K-Pg extinction event.



**Figure 1.** Cardinal view of an adult *Coralliochama orcutti*. Drawing from White, 1885: Plate II.

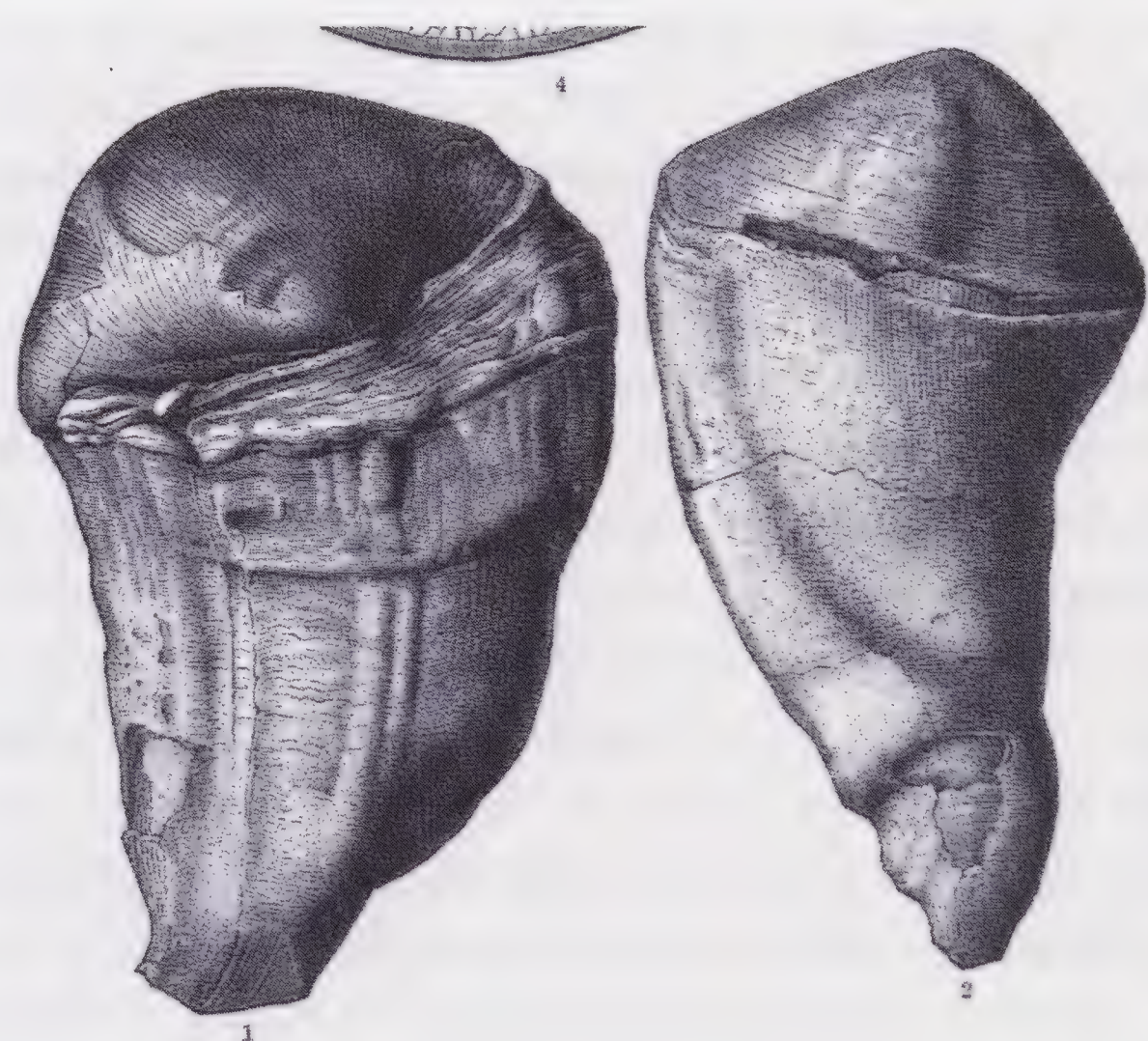


**Figure 2.** Cardinal view of a partly grown *Coralliochama* (left), and an opposite view of another specimen. Both drawings showing the upper valve in natural position. Drawings from White, 1885: Plate IV.



In life, the greatly elongated right valve was cemented to the substrate, and then grew conically upwards (Figure 1). “Test thick, consisting of three layers, the outer one being prismatic, the middle cellular, and the inner porcellaneous. The space which was occupied by the animal was very small as compared with the bulk of the shell, and it is situated eccentrically. Lower valve irregularly subconical, more or less distorted, much deeper than the other valve; beak distorted as a consequence of its attachment to a foreign object; ligamental groove more or less distinct, extending from the apex to the lunge margin” (White, 1885). The convex upper left valve (Figure 2) is much smaller, lying across the right valve and growing to keep pace as a lid over the widening open end of the cone. It has a broad beak and is “incurved to the hinge margin of the lower valve...[L]igamental groove marginal; internal cavity partially divided into unequal parts by a more or less prominent longitudinal septum” (White, 1885). Total length of undeformed shells can reach 25.5 cm (10 in.).

The animals grew separately or in clusters, often attaching themselves to each other. Because they commonly grew huddled together on flat surfaces or steeply inclined slopes, shell shape and size are quite variable (Götz *et al.*, 2005). Beds of the *Coralliochama* are up to 100 cm thick.

Five species of turbinid, neritid and cerithid gastropods are irregularly distributed throughout the same strata occupied by *Coralliochama orcutti* in Baja California, four named by White (1885), and one recently named in honor of LouElla Saul, *Trocotaulax saulae* Kiel & Aranda, 2002. Based on the habitat requirements of modern representatives of these snails, the paleoenvironment of the *Coralliochama* beds was likely shallow, warm water, with adjacent brackish and sea water habitats (Saul, 1970). These rudists probably lived below mean wave base in a shallow-water lagoon, a low-energy environment periodically affected by storm waves or currents (Marincovich, 1975). The neritid *Neritoplica californiensis* (White, 1885), and the cerithids *Echinoaxis pillingi* (White, 1885), *Tympanotonos (Exechocirsus) totiusanctorum* (White, 1885) and *Trocotaulax saulae* likely lived in the brackish intertidal, while the turbinid *Homalopoma euryostoma* (White, 1885) is assumed to have lived in a subtidal lagoon with *Coralliochama* (Kiel & Aranda, 2002). There were apparently steep wave-washed bedrock cliffs with local pocket beaches along the nearby shoreline (Squires, 1993).

Californian and Baja Californian Upper Cretaceous deposits that currently lie west of the San Andreas fault “form part of a superbly exposed convergent margin basin complex. The Late Cretaceous Rosario Formation in northern Baja California forms part of this complex and was deposited in a highly mobile forearc, strike-slip basin” (Götz *et al.*, 2005). The basal Rosario Formation was deposited in distinctive windward and leeward settings, forming a small near-shore peninsula-island. “The windward side of the island is dominated by a thick, homogeneous wedge of andesite clasts reduced to small cobbles and pebbles in a limestone matrix. Crustose coralline algae referable to the genus *Sporolithon* prolifically encrust virtually all the clasts. The rudist bivalve *Coralliochama orcutti* is the only other abundant organism and it is found in life position cemented to the andesite substrate” (Johnson & Hayes, 1993).

The original site of deposition, ~70-75 million years ago, was farther to the south, based on the warm water fauna. This warm water fauna indicates deposition at paleolatitudes of ~20° N to ~26° N. Considerable northward transit by exotic terrains and as fault blocks, both prior to and after the



Oligocene initiation of the San Andreas transform fault system, have translated these rocks to their present latitudes of 38° 46' N and 31° 51' N (Elder, Saul & Powell, 1998).

This species is the only currently accepted member of the monotypic genus *Coralliochama*.

Twenty years ago, UABC geology professor Dr. Miguel Téllez Duarte and I led the first Western Society of Malacologists' field trip to México. We made stops (Téllez Duarte & Bertsch, 2003) to see the numerous indigenous coastal midden mounds, and multiple Pleistocene, Pliocene, Miocene and earlier fossil sites, including the magnificent ammonite cast of *Pachydiscus (Neodesmoceras) catarinae* (Anderson & Hanna, 1935), located above the school yard of CET-MAR in El Sauzal. Our final field stop was at the *Coralliochama* beds at Punta Banda. Crossing the raised former-sea-level terrace, we climbed down the cliff to view the scrambled rocks and fossils (Figures 3-5). It was truly a trip across the weavings of the space-time continuum!

### ***Chlamydoconcha orcutti* Dall, 1884**

It began with a letter I received in the mail from Hong Kong in December 1979 when I was Curator of Marine Invertebrates at the San Diego Natural History Museum. Brian Morton was planning to attend a meeting in Texas and wanted to know if he could stop at San Diego for me to collect some living *Chlamydoconcha orcutti* for him to examine. When I agreed, he changed his international flight plans to include a stopover in San Diego. I was a bit worried, since it is a rare animal, and I had never collected it. The solution was to phone my colleague and dear friend, Dave Mulliner, San Diego's pre-eminent scuba-diving mollusk expert and member of the San Diego Shell Club, and ask, "Where?" "Among the jetty rocks on the south side of the entrance to Mission Bay." Dave was right, and I found two animals alive under the same rock. Dr. Morton spent several days in my lab at the museum, observing and dissecting them.

Personally, it is one of my favorite clam species, not just because it looks like a nudibranch, but because of its marvelous evolutionary adaptations to shell loss and to finding a mate.

When William H. Dall received some 50 specimens of this animal that Orcutt had collected in Mission Bay, he considered it "a very remarkable new form of Mollusca... This animal is a pelecypod or lamellibranch with an internal shell. Nothing of the sort, or in the least approaching it, has ever been described.... It is evident already, that the genus does nothing toward bridging the gap between the gastropods and pelecypods, but is simply a remarkable aberrant form of the latter group, and probably derived from some form with an external shell" (Dall, 1884).

*Chlamydoconcha orcutti* is now placed within the superfamily Galeommatoidea Gray, 1840, a clade that has evolved a unique suite of specializations. Members commonly have a muscular foot modified for snail-like locomotion. "Trends within the group are toward shell reduction, with corresponding reductions in sculpture, hinge structure and adductor muscles,...reduction of the outer demibranch, commensalism, and reproductive specialization, including hermaphroditism, brooding, dwarf males, and mating behavior" (Bieler & Mikkelsen, 1992). This genus has reached an extreme degree of the family's "trend towards reduction of the shell and the reflection of the middle mantle



fold over it progressively to assume greater responsibility for protection” (Morton, 1981). [N.B. Unless otherwise stated, all cited page numbers below are from Morton’s article.]

The living animal is globose (Figures 6-9), with an elongate oval appearance, reaching about 25 mm in extended length (Figure 10). The animal is “translucent white with a large anterior, inhalant siphon” (p. 86), lying over the top of the protruding foot. “The dorsal surface of this siphon forms a cowl giving a very clear impression of a nudibranch sea slug” (p. 86). Dall used this feature in naming the genus: *Χλαμύς* (= chlamys, Greek for a cloak), and *κογχή* (= concha, Greek for shell).

Small, round opaque white dots are scattered over the animal’s body. These are eversible papillae (retractable into pits), forming the openings of secretory tubules, which likely extrude defensive chemicals. This is an intriguing example of convergent evolution with the mantle glands of the chromodorids and other nudibranchs!

Arising from the mantle’s dorsum (Figure 11) is “an enormous anemone-like structure, comprising a circular disc of papillae, all of which can be withdrawn” (p. 86). Morton (p. 81) “hypothesized that this structure is a pheromone organ releasing an attractant to guide the swimming larvae not only to the adult but more specifically to the pore leading down to the shell, embedded in the mantle. In a sparsely distributed species such a signaling device is essential” (p. 81).

“The foot of *C. orcutti* is large and possesses a small byssus, which attaches the adult to the under-surface of rocks in the shallow sublittoral. When detached, however, the animal is very active and there is a constant and reciprocal flow of fluids (blood) between the large foot and the greatly inflated middle mantle folds. Both foot and mantle act as blood reservoirs allowing the expansion and contraction of the former during locomotion” (p. 81).

“The adult shell (Figure 12) is completely internal because the middle mantle fold has grown up and over the animal’s body, completely enclosing the shell” (Bertsch, 1984). Approximately 10 mm in length, it is lanceolate, long, and “narrow, with small anterior umbo and distinctive subglobular prodissoconch” (Coan, Valentich Scott & Bernard, 2000: 313). There is a single anterior adductor muscle. Two anterior and posterior pedal retractor muscles are present, and one anterior pedal protractor.

When Brian visited me in January 1980, I collected several sexually mature adults, which he examined. They were hermaphrodites, though structurally mainly female. A small male lives inside the larger female, fertilizing the sperm. “Just behind the pheromone organ [of the adult female] is a tiny pore which forms a duct leading down to the space between the mantle and the periostracum of the [adult] shell. Here, and attached to the periostracum by its byssus, is found the dwarf male and the tube constitutes its contact with the water above” (p. 95). “The dwarf male releases spermatozoa, which are probably inhaled via the cowl-like inhalant siphon to fertilize the eggs of the female” (p. 114). Another animal I had previously collected was also an adult female incubating a mass of fertilized eggs among both demibranchs of both ctenidia.



*Chlamydoconcha orcutti* has been found at numerous locations, from the shallow subtidal to 38 m deep, between Shell Beach, Sonoma County, California, to Punta San Pablo, Baja California Sur, México (Carlton, 1975).

While scuba diving off the southern end of South Coronado Island, Baja California, on 1 March 1980, I found three *C. orcutti* under a rock. One was dislodged into the water column as I overturned the rock. A garibaldi fish, *Hypsypops rubicunda*, was swimming nearby, approached, and then ate the naked clam in one swallow. I guess its taste buds bypassed the distaste.

A second species of this genus has recently been described from southeastern Brazil in the Atlantic Ocean: *Chlamydoconcha avalvis* Simone, 2008.

## CONCLUSION

In addition to Orcutt's fascination for cacti and plants, I suspect he held these two clams in special regard.

NOTE: Please remember that various Mexican federal and Californian state laws protect these fossil and living organisms from collection. What you see is best shared with your family and friends, in a well-told tale or a well-taken photograph.

## ACKNOWLEDGMENTS

The communication of science involves a community. Mine was very generous to me. I thank Herb Gruenhagen and Kevin Lee for allowing me to use their great photos. I am grateful to Lindsey Groves, Charles L. Powell, II, Paul Valentich-Scott and Robert Dees for providing important advice and information during the writing of this article.

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**Figure 3.** Image of fossil rudist beds at Punta Banda. Photo by Hans Bertsch, June 2001, during Western Society of Malacologists' field trip.



**Figure 4.** *Coralliochama* shells, Punta Banda. Photo by Hans Bertsch, June 2001.



**Figure 5.** *Coralliochama* shells, 200 mm in length Punta Banda. Photo by Hans Bertsch, June 2001.



**Figure 6.** Living *Chlamydoconcha orcutti*, ~25 mm in length, lateral view with extended foot. Photo by Antonio J. Ferreira, May 1973, Monterey Bay, California.



**Figure 7.** Living *Chlamydoconcha orcutti*, lateral view with defensive papillae clearly visible. Photo by David K. Mulliner, November 1970, Pyramid Cove, San Clemente Island, California, 13 m deep.



**Figure 8.** Living *Chlamydoconcha orcutti*, mantle and foot. Photo by Kevin Lee, 17 October 2015, Resort Point, Palos Verdes, California, 22.8 m deep.





**Figure 9.** Dorsal photograph of living *Chlamydoconcha orcutti*. Photo by Herb Gruenhagen, 19 June 2017, La Jolla Shores, San Diego, California, 19.8 m deep.

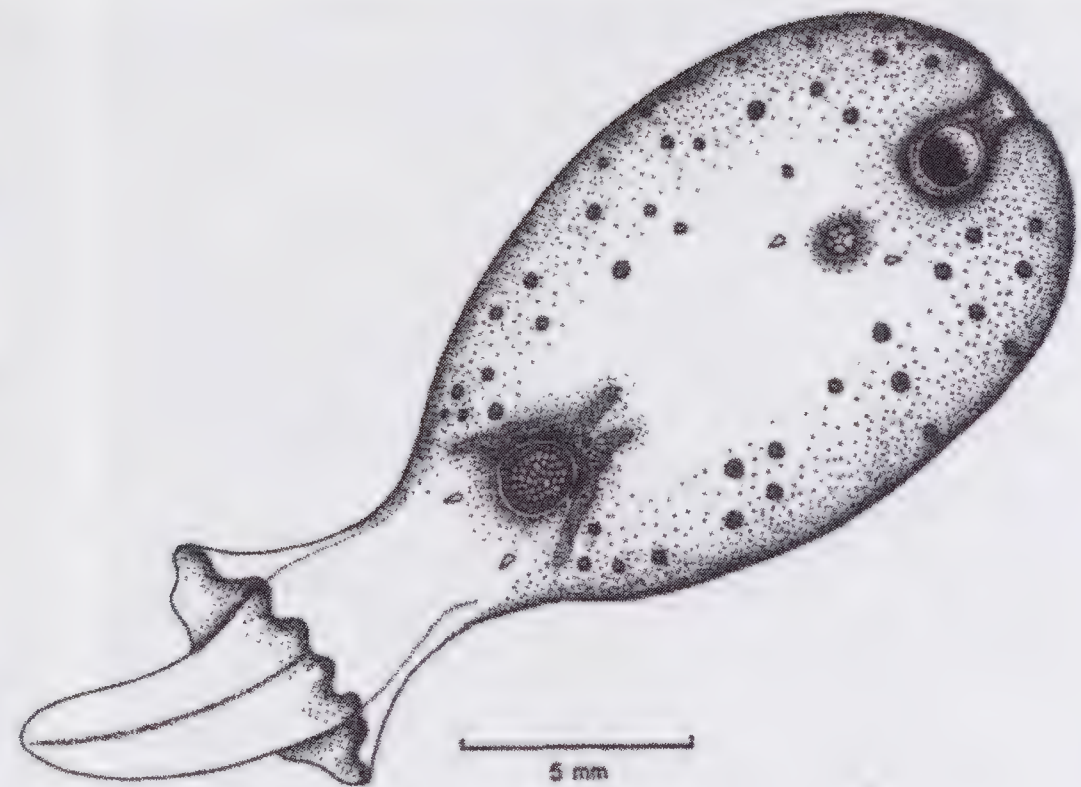


**Figure 10.** Drawing of dorsal surface of living animal, pheromone organ (lower left) and exhalant siphon (upper right) clearly shown. Drawing from Morton, 1981: Figure 1.

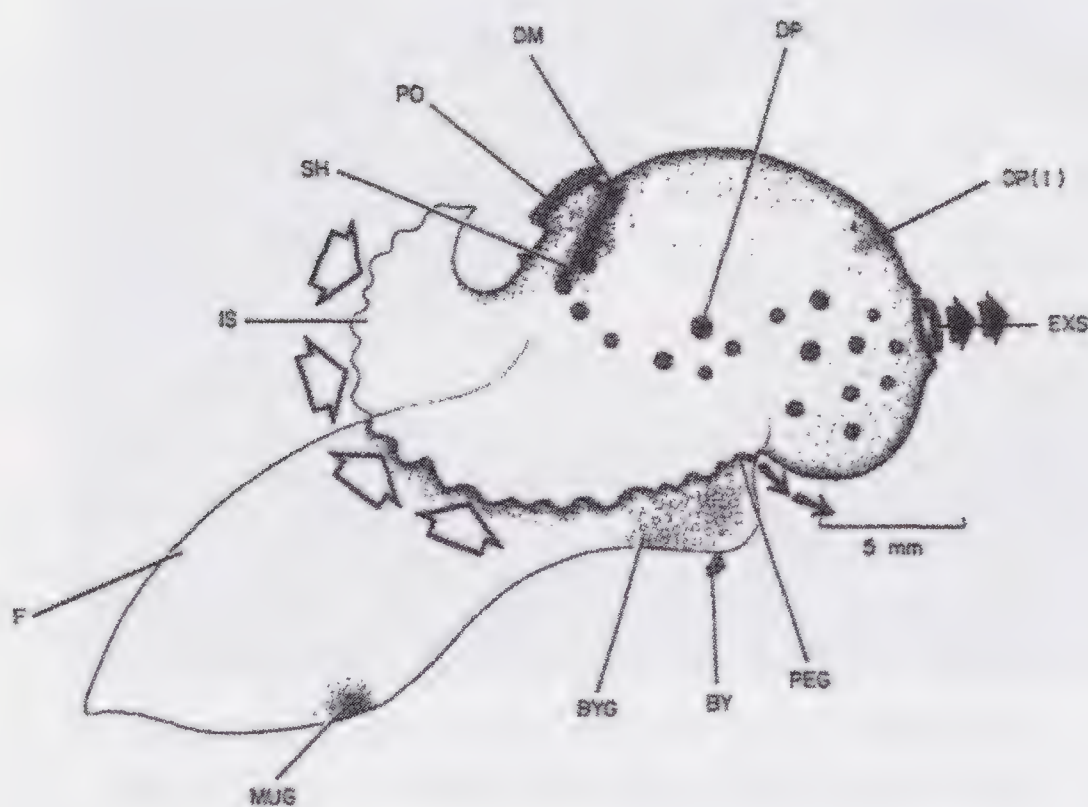


**Figure 11.** External anatomical features of *Chlamydoconcha orcutti*. BY = byssus; BYG = byssus gland; DM = dwarf male; DP = defensive papilla; DP(1) = major defensive papilla; EXS = exhalant siphon; F = foot; IS = inhalant siphon; MUG = mucous gland; PEG = pedal gape; PO = pheromone organ; SH = shell. Large open arrows = inhalant stream; large solid arrows = exhalant stream; small solid arrows = pseudofeces. Drawing from Morton, 1981: Figure 2.

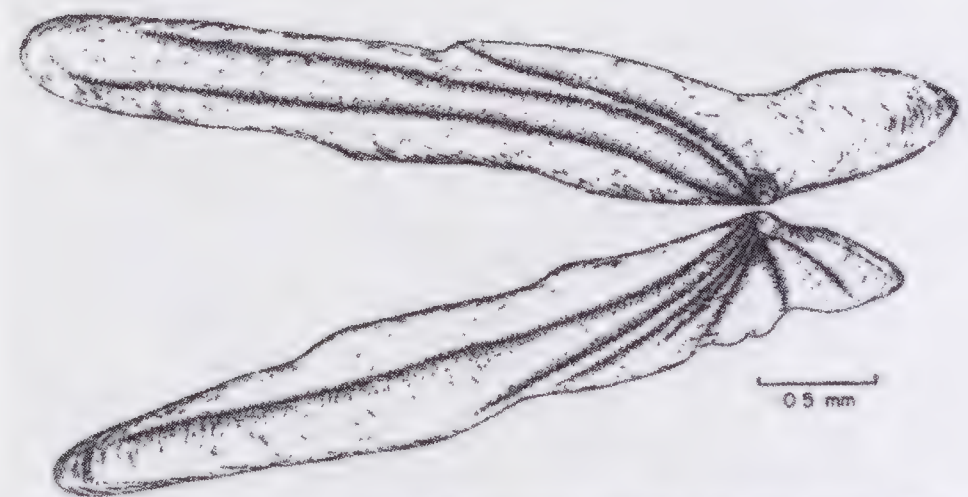


FIG. 4. *Chlamydoconcha orcutti*. External view of the adult shell: above, the right; below, the left valve.

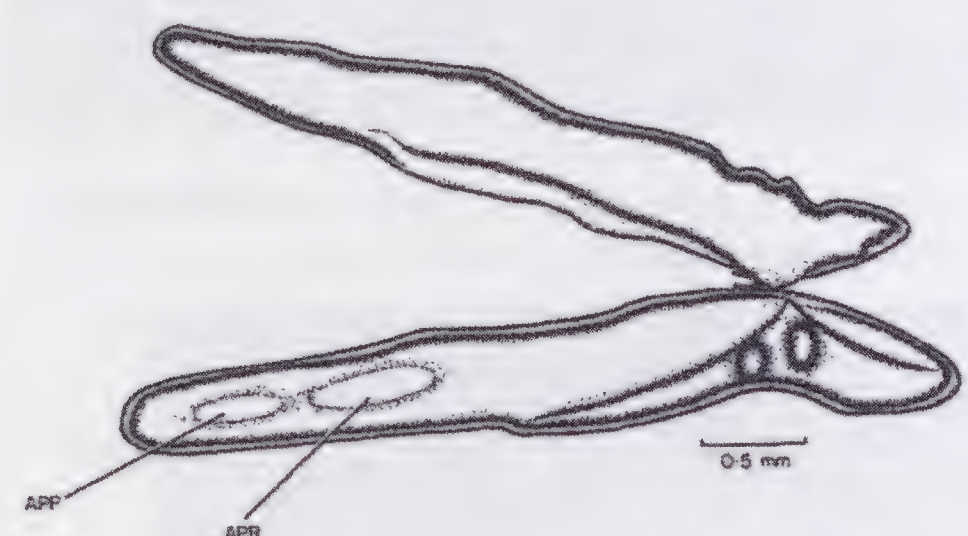


FIG. 5. *Chlamydoconcha orcutti*. Internal view of the adult shell: above, the left; below, the right valve. (For abbreviations see p. 121.)

**Figure 12.** Drawings of shell of *Chlamydoconcha orcutti*. Top, external views of valves; right valve is above. Bottom, internal views; left valve above. APP = anterior pedal protractor muscle or scar; APR = anterior pedal retractor muscle or scar. Drawings from Morton, 1981: Figures 4 and 5.





*E. adansonianus adansonianus* (Crosse & Fischer, 1861), Bahamas, 106.1 mm. *B. poppei* (Anseeuw, 2003), Tonga Islands, 58.8 mm. *P. amabilis f. maureri* Harasewych & Askew, 1993, USA, 42 mm. *B. tangaraana* (Bouchet & Métivier, 1982), New Zealand, 55.9 mm. *P. quoyanus* (Fischer & Bernardi, 1856), Curaçao, 50.7 mm. *B. philpoppei* Poppe, Anseeuw & Goto, 2006, Philippines, 65.1 mm. *B. charlestonensis* Askew, 1987, Martinique, 77.3 mm. *B. midas* (Bayer, 1965), Bahamas, 82.7 mm.

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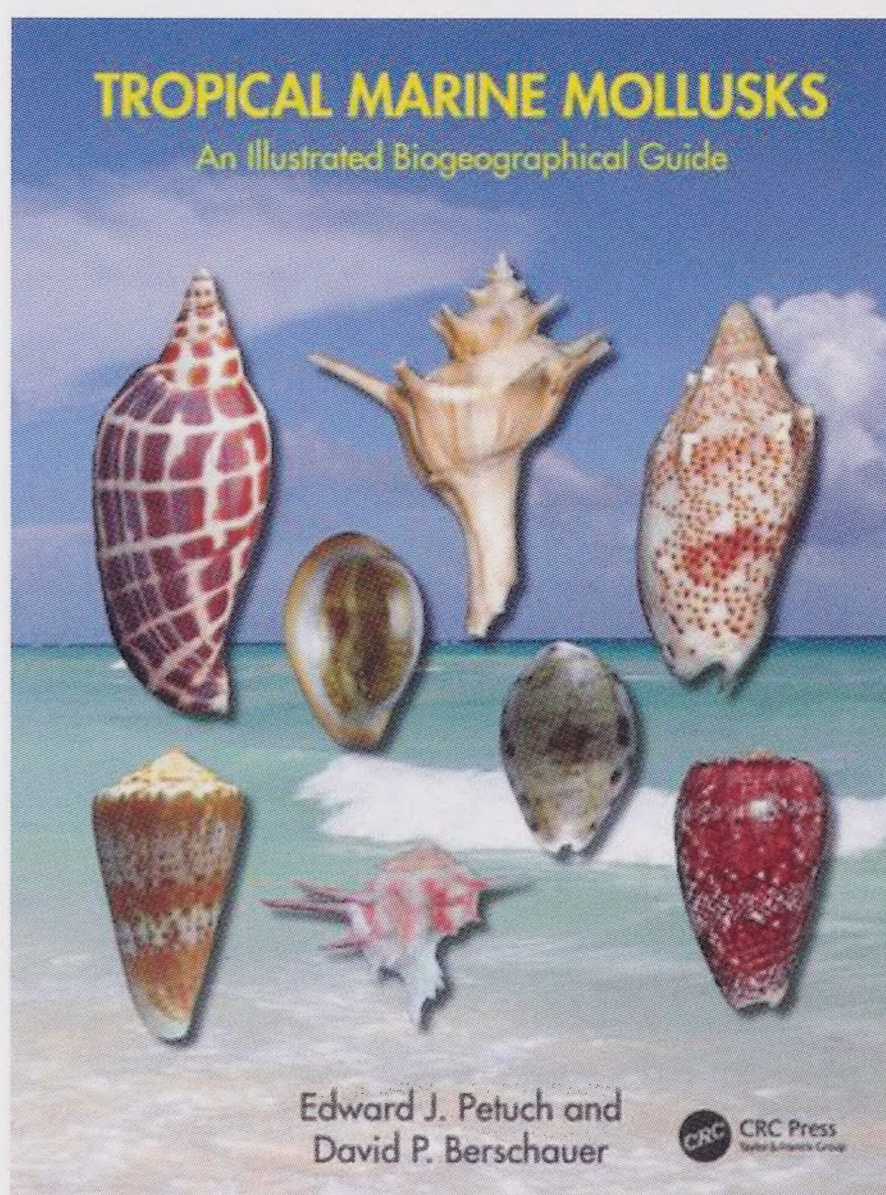


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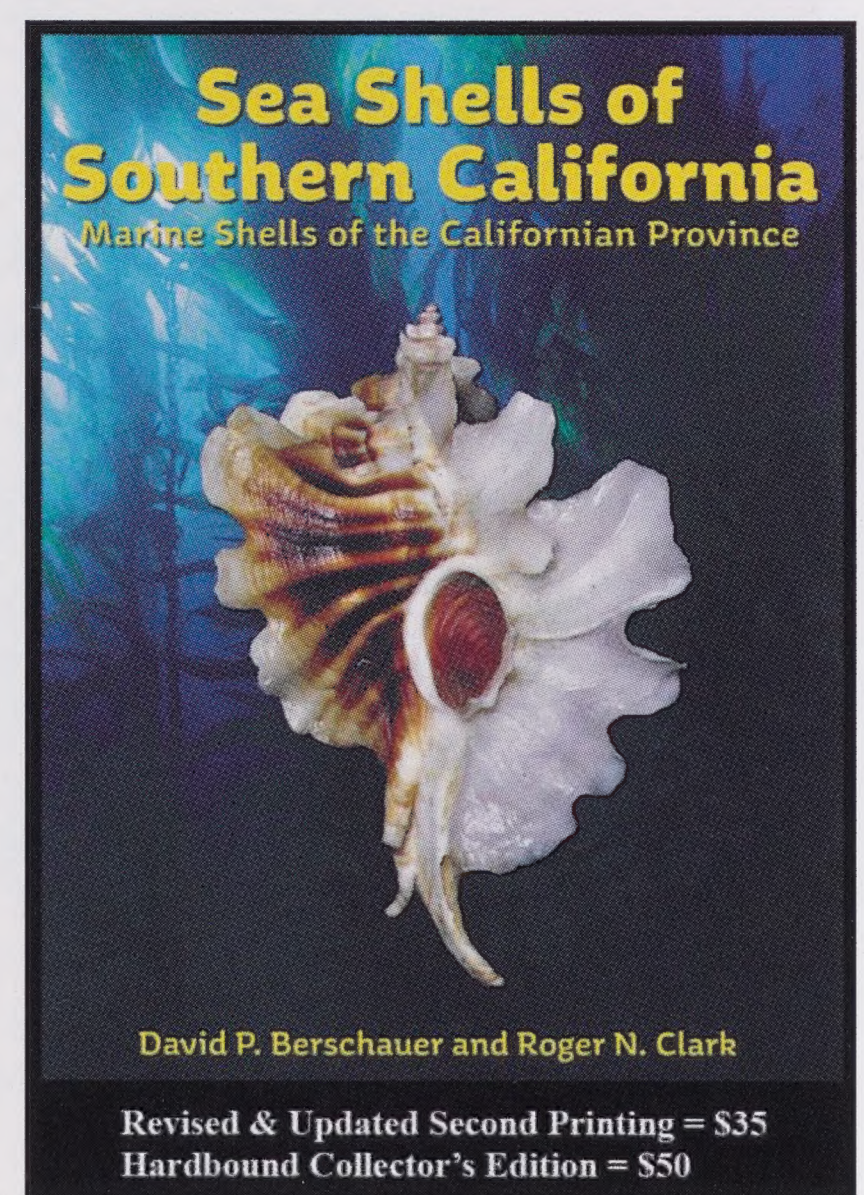


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